

FOREWORD

This investigation was conducted for the NASA Langley Research Center by the Convair Aerospace Division of General Dynamics Corporation under Contract NAS 1-11431.

The NASA Technical Monitor was Dr. Robert E. Fulton, Head, IPAD Technology Section, Design Technology Branch, Structures and Dynamics Division, assisted by Dr. Jaroslaw Sobieszczanski and Mrs. Susan J. Voigt. The Convair Project Leader was Mr. C. A. Garrocq, assisted by Messrs. M. J. Hurley, M. Dublin, J. J. Hosek, O. E. Wheeler, R. A. Westerwick, R. H. Trelease, J. S. Barron, G. W. Bradfield, J. D. Sutliff, W. J. Moran, A. Karemaa, R. T. Schemensky, L. A. Evans, D. S. Osterle, R. G. Huntington, J. L. Howse, H. Roland, R. W. McMickle, K. C. Bonine, J. E. Meyer, R. H. Schappelle, D. Kurpiewski, S. K. Pederson, R. Howe, N. E. Tipton, A. H. Cooper, G. M. Oing, J. M. Maughmer, W. E. Jenkins, T. M. Wooster, J. C. Mallory, B. H. Oman, D. W. Peterson, P. K. Shih, D. R. Diaddigo, R. E. Kenyon, B. J. Kuchta, J. D. Neilson, J. T. Gordon, and H. W. Buckner.

The Control Data Corporation participated in the performance of this study as a subcontractor to the General Dynamics Corporation.

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SUMMARY

The purpose of this study was to determine the feasibility of an IPAD system, define its operating philosophy and organization, and generate an IPAD system design featuring the best approach identified during the study.

The study was divided in two phases encompassing eight tasks. An overall study summary is reported in Volume I. The detailed results of Phase I (Tasks 1 and 2) are reported in Volumes II to V. Volume VI includes the results of Phase II (Tasks 3 to 8).

An evaluation of the design process, as viewed through the activities of various design and engineering disciplines, was performed to segregate the basic creative and evaluation procedures used in the design of an aircraft project. Volumes II and III present the results of the evaluation. This effort yielded a specific set of disciplinary functions required, and identified available automated procedures that can be used in an IPAD system. It also identified a series of procedures presently carried out by hand and further developments that are needed to automate these latter analyses and to conduct the whole design process in a more efficient, cost-effective manner. By reviewing the participation of various disciplines within a project design team, a usage philosophy was evolved whereby the user -- the engineer -- is the focal point of the IPAD concept. This concept involves two major ingredients; an Engineering Capability consisting of a battery of Operational Modules, and a Computer Software/Hardware Complex where that capability will be installed and exercised. The engineering capability is modular and will be tailored to the specific needs of the project team, while the computer complex could be essentially the same for all teams, barring differences among computing systems.

The principal mode of operation is using interactive graphics equipment. The system also includes less sophisticated interactive terminals as well as the common batch mode operation. Details can be found in Volumes III and IV.

A First Release Capability for IPAD is recommended consisting of engineering operating modules, computer systems software and required computer hardware and peripheral equipment. Details of this recommendation can be found in Volume I, Section 2.4.

This volume includes a series of Functional Flow Charts that were developed to properly identify and record the degree of participation of the disciplines considered in this feasibility study and the type of data required in the design process. A discussion of these charts is given in Volume II, Chapter 3.

1 INTRODUCTION

The design of a new aerospace vehicle is presently a complex, long-term process. At the onset, a set of objectives is identified in the areas of mission, weight, performance, payload, range, etc.; which are specified with a fairly good knowledge of the available design technology and constraints. The designer's goal is to minimize cost, while meeting basic project objectives. The designer possesses a fund of accumulated experience and knowledge which he applies, with intuition, to the requirements and constraints he has been given. The knowledge and experience of the designer are more and more frequently being delegated to the computer; the intuition and imagination can never be. Some of the purposes of the IPAD feasibility study were to determine what sections of the design process are amenable to automation; how much monitoring must the automation have; how can the design process be effectively organized; and, most important, how can the management/designer/engineer team members retain the visibility and control necessary to exercise their intuition and imagination in the design process.

The introduction of automation is a significant change in the design process; however, the important management aspects of this change are not only related to the technical details of engineering disciplines, programming, data bases, etc., but the key to success also depends upon managing the adaptation required of the people involved in the use of the automated process.

Automation of any process requires not only a thorough knowledge of the process, but of the pivotal factors that drive and control it. When the process involves the myriad details of project team data flow and communications, many programs and subroutines, thousands of variables, and the ramifications of computer operating system characteristics, it is easy to lose sight of the fact that it is still the designer - the engineer - who is the key driver and decision-maker in the process.

Although the various volumes of this report describe some of the considerations necessary for the technical basis needed to successfully automate the design process, the underlying, guiding philosophy has been that of providing a tool adapted to the needs of the members of a management/designer/engineer team--the ultimate users--and that is a truly useful tool. The acknowledged principle has been that the engineer and his management are generally more interested in solving the design problem than in becoming a better communicator with the computer.

The scope of the total IPAD feasibility study is illustrated in Figure 1-1. The study was divided into the following eight tasks within two study phases:

STUDY PHASE I
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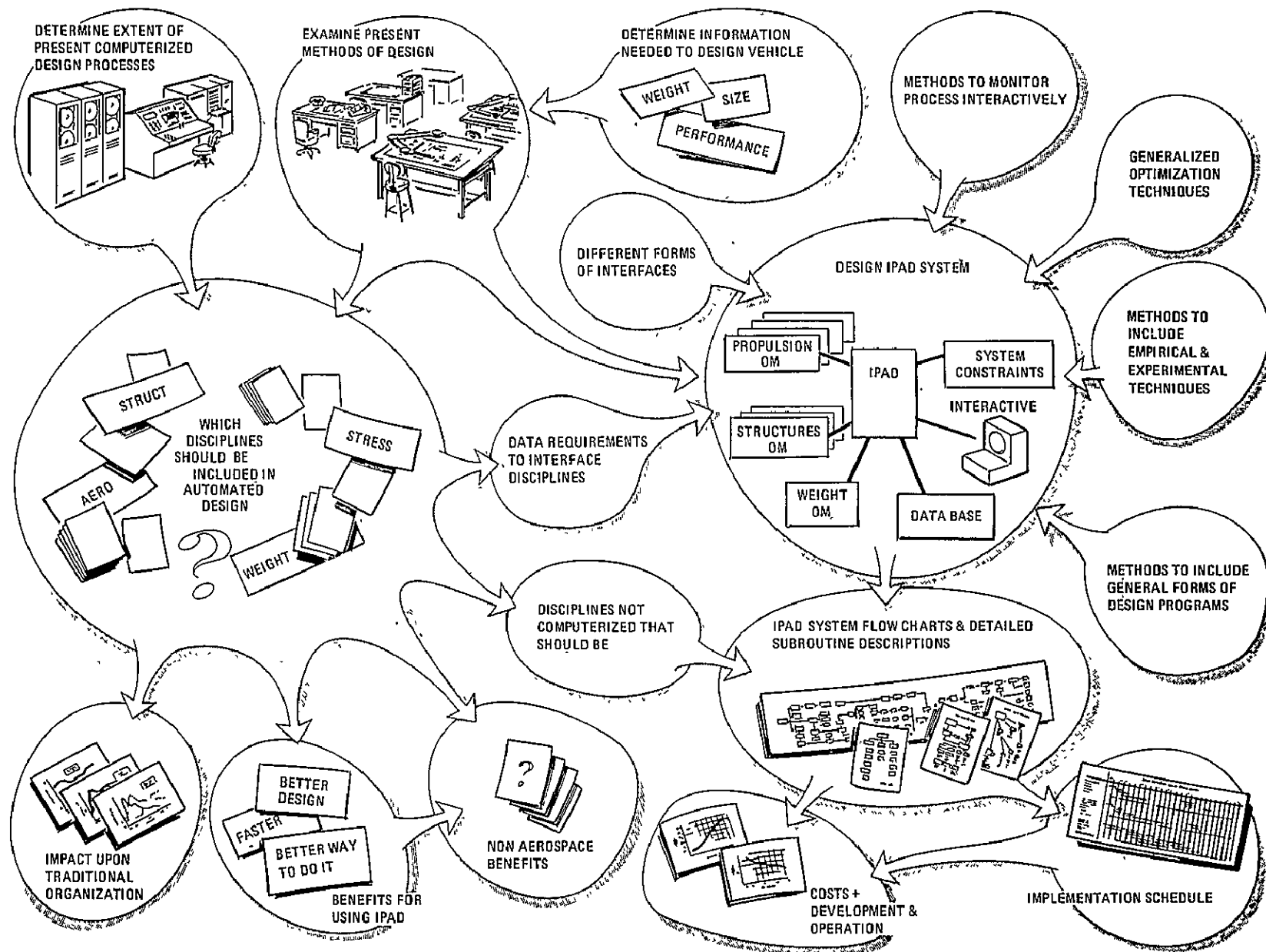


Figure 1-1. IPAD Study Flow Chart

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PHASE I

STUDY PLAN COORDINATION

TASK 1 - CHARACTERIZATION OF IPAD SYSTEM

- Define an IPAD Engineering Usage Philosophy
- Identify Feasible Automated Design Procedures
- Evaluate Adequacy of Existing Computer Programs
- Recommend Areas for Further Development
- Determine IPAD Feasibility and Applicability
- Recommend IPAD's First Release Engineering Capability

TASK 2 - DESIGN OF IPAD SYSTEM

- Define a Systems Operating Philosophy
- Evaluate System Design Options
- Identify Elements of IPAD's Utility Library
- Investigate Organization and Management of Data Bank
- Determine Number and Type of Input/Output Terminals
- Determine Host Computer Complex Configurations Adequate for IPAD
- Recommend IPAD's First Release Computer System Capability

PHASE II

TASK 3 - IPAD IMPLEMENTATION SCHEDULE

TASK 4 - IPAD SYSTEM DEVELOPMENT COST

TASK 5 - IPAD SYSTEM OPERATIONAL COST

TASK 6 - IPAD SYSTEM BENEFIT ASSESSMENT

TASK 7 - IPAD IMPACT ON COMPANY ORGANIZATION

TASK 8 - IPAD SPIN-OFF ASSESSMENT

Figure 1-2 summarizes the main features of an IPAD system as presently conceived and described elsewhere in this report.

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IPAD IS:

- AN INTEGRATED SYSTEM OF AUTOMATED MODULES.
EACH DISCIPLINE IS RESPONSIBLE FOR ITS OWN CAPABILITY DEVELOPMENT, UPDATE & GROWTH
- A USER-ORIENTED & DIRECTED MODULAR SYSTEM WITH FLEXIBILITY FOR CHANGE, ADAPTATION & EXPANSION
- A HARDWARE/SOFTWARE COMPUTER SYSTEM DESIGN APPROACH
TO PERFORM ENGINEERING DESIGN PROCESSES MORE EFFECTIVELY, ECONOMICALLY & SWIFTLY
- A COMPUTER SYSTEM STRUCTURE
USABLE IN MANY ENGINEERING & SCIENTIFIC FIELDS
- ITS DATA BANK IS THE REPOSITORY FOR ALL DESCRIPTIVE & INFORMATIVE DATA
GENERATED BY THE ENGINEERING/SCIENTIFIC TEAM FOR A SPECIFIC PROJECT
- A MANAGEMENT TOOL
TO PROVIDE IMMEDIATE VISIBILITY INTO PRODUCT STATUS & PROGRESS
- INITIALLY, A REASONABLE ENGINEERING CAPABILITY (SET OF AUTOMATED MODULES) MOUNTED ON A STATE OF THE ART HARDWARE/SOFTWARE STRUCTURE
THAT CAN BE READILY IMPLEMENTED
- ULTIMATELY, A COMPREHENSIVE, DYNAMIC ENGINEERING TOOL SUPPORTED BY
EFFICIENT, COST-EFFECTIVE HARDWARE/SOFTWARE CAPABILITY
- AN EDUCATIONAL AID FOR TRAINING NEW ENGINEERS IN THE USE OF VARIOUS
DESIGN PROCESSES

IPAD IS NOT:

- A SINGLE, HARDWIRED COMPUTER PROGRAM
- AN AUTOMATED, SINGLE-PURPOSE PROCEDURE
- A DISLOCATED ARRAY OF RANDOMLY COLLECTED COMPUTER PROGRAMS
- A SYSTEM OF PROGRAMS TO BE RUN BY A SINGLE DISCIPLINE
- A SYSTEM OF PROGRAMS IMPOSED BY AN AGENCY (OR COMPANY) ON THE
AEROSPACE INDUSTRY COMMUNITY

Figure 1-2. Major IPAD Features

2 THE IPAD SYSTEM DESIGN. OBJECTIVES

The overall goal of IPAD is the automation of appropriate sections of the design process to shorten design time, reduce cost, and improve the ultimate product.

The objectives of the present study were to:

- Develop IPAD's Operational Philosophy
- Establish Extent of IPAD Support of the Design Process
- Investigate System Organizational Options
- Determine the Feasibility of an IPAD System
- Generate an IPAD System Design
- Recommend IPAD's First Release Capability

A series of studies were performed in pursuit of these objectives including the following:

1. Design Process

- a. Characterize the design process dividing it in various design phases, and segregate the basic functions performed by several representative design/engineering disciplines in each phase.
- b. Identify the interdisciplinary data flow for manual/automated procedures and man-machine interfaces occurring in the design process.
- c. Evaluate the adequacy of existing computer programs and operating modules for use in IPAD.
- d. Define an IPAD usage philosophy from the engineering user point of view.
- e. Identify optimization techniques to be included within an IPAD system.
- f. Recommend IPAD's first release engineering capability.

2. Computer System.

- a. Define the system operating philosophy and evaluate system design options.
- b. Investigate the organization and management of the Data Bank.
- c. Identify and describe the software elements of a Utility Library for IPAD.
- d. Determine the number and type of Input/Output Terminals.
- e. Determine host Computer Hardware/Software Complex configurations adequate for IPAD.
- f. Evaluate language and size limitations of existing operational modules.
- g. Recommend IPAD's first release computer system capability.

3 DESIGN PROCESS FLOW CHARTS

This section presents flow charts of the design process for aircraft and of pertinent Creative/Evaluation Processes as discussed in Volume II, Chapter 3 of this report.

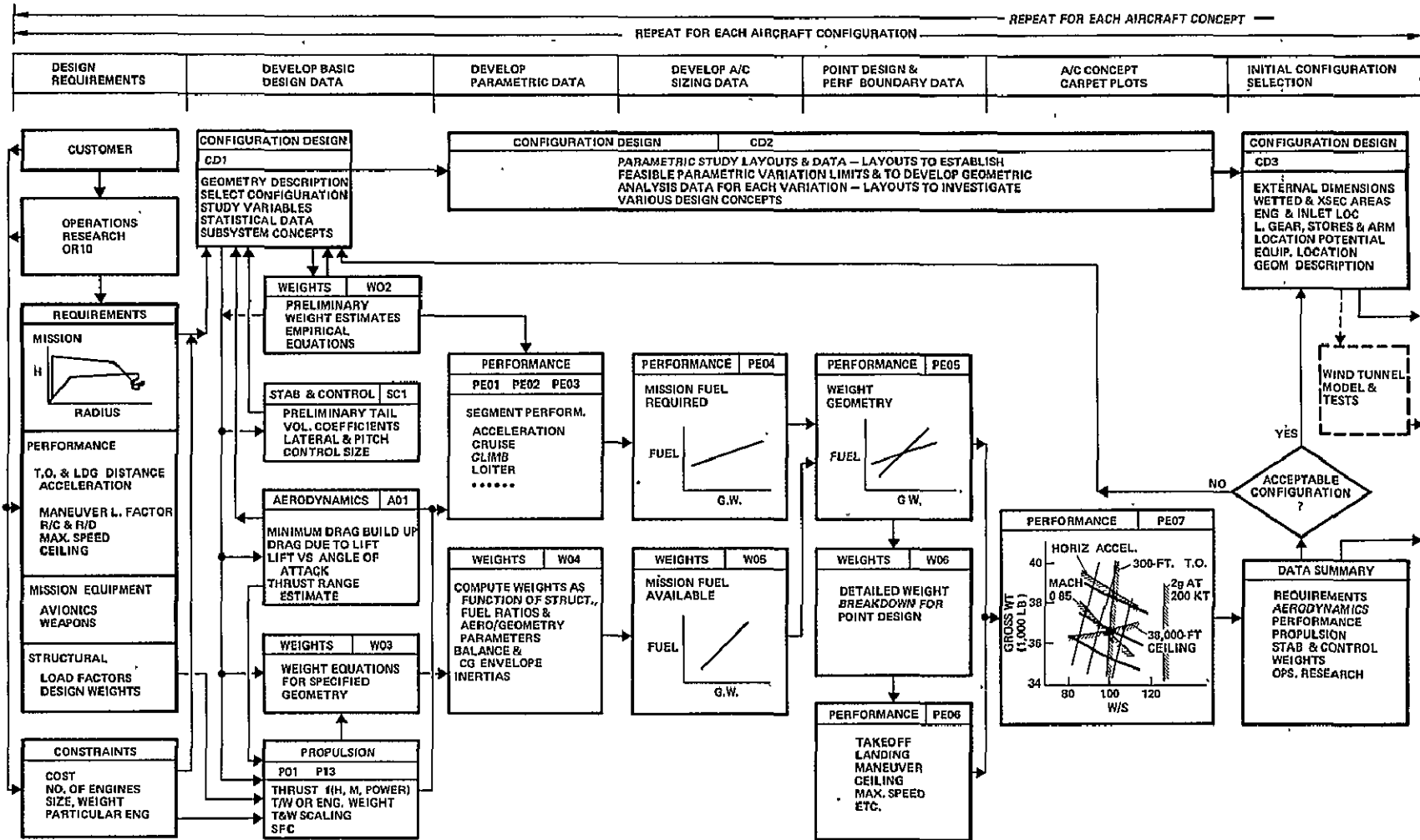


Figure 3-1. Conceptual Design Phase, Continued

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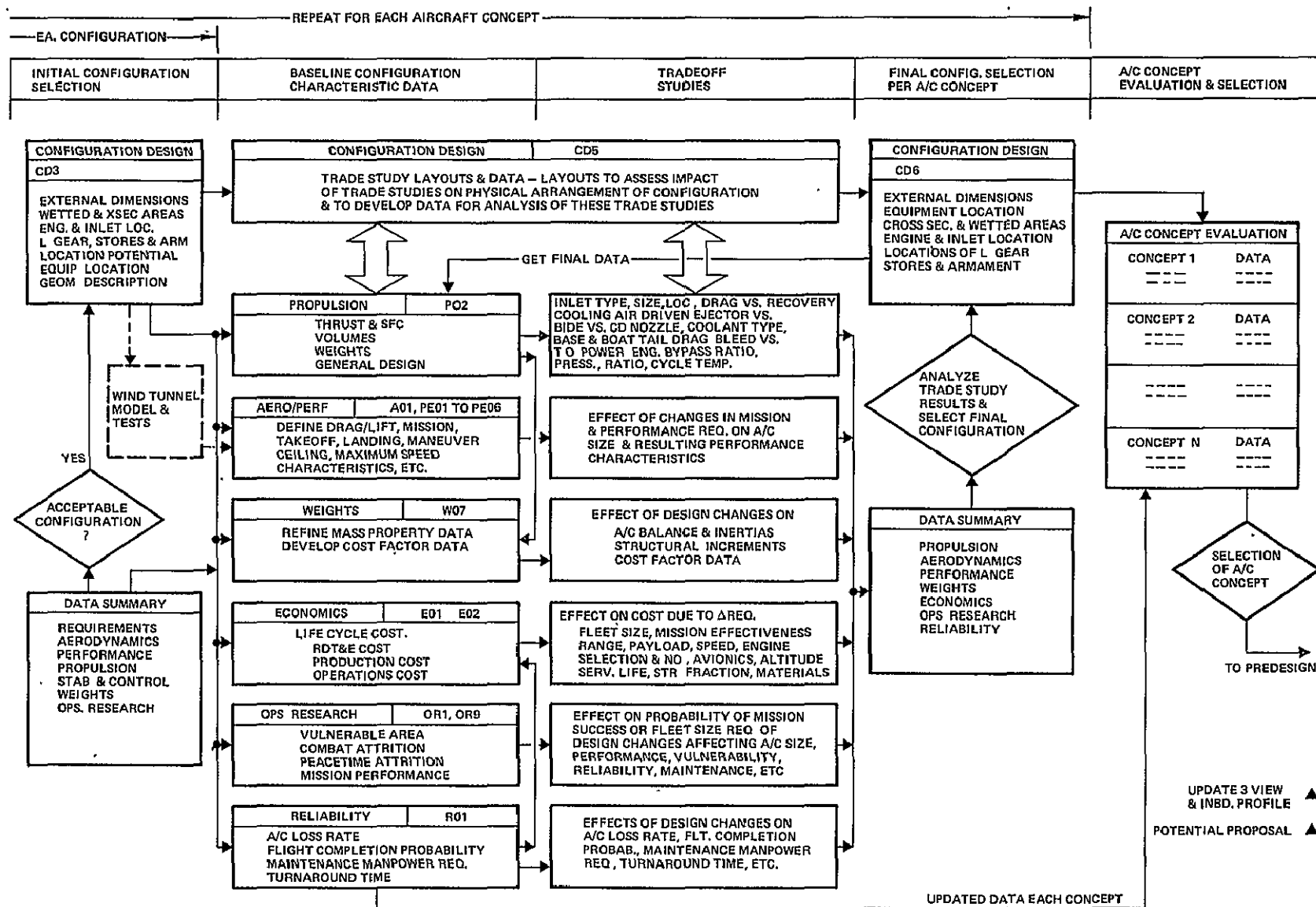


Figure 3-1. Conceptual Design Phase, Concluded.

Creative/Evaluation Process (CEP)

DISCIPLINE: _____ DESIGN PHASE: _____

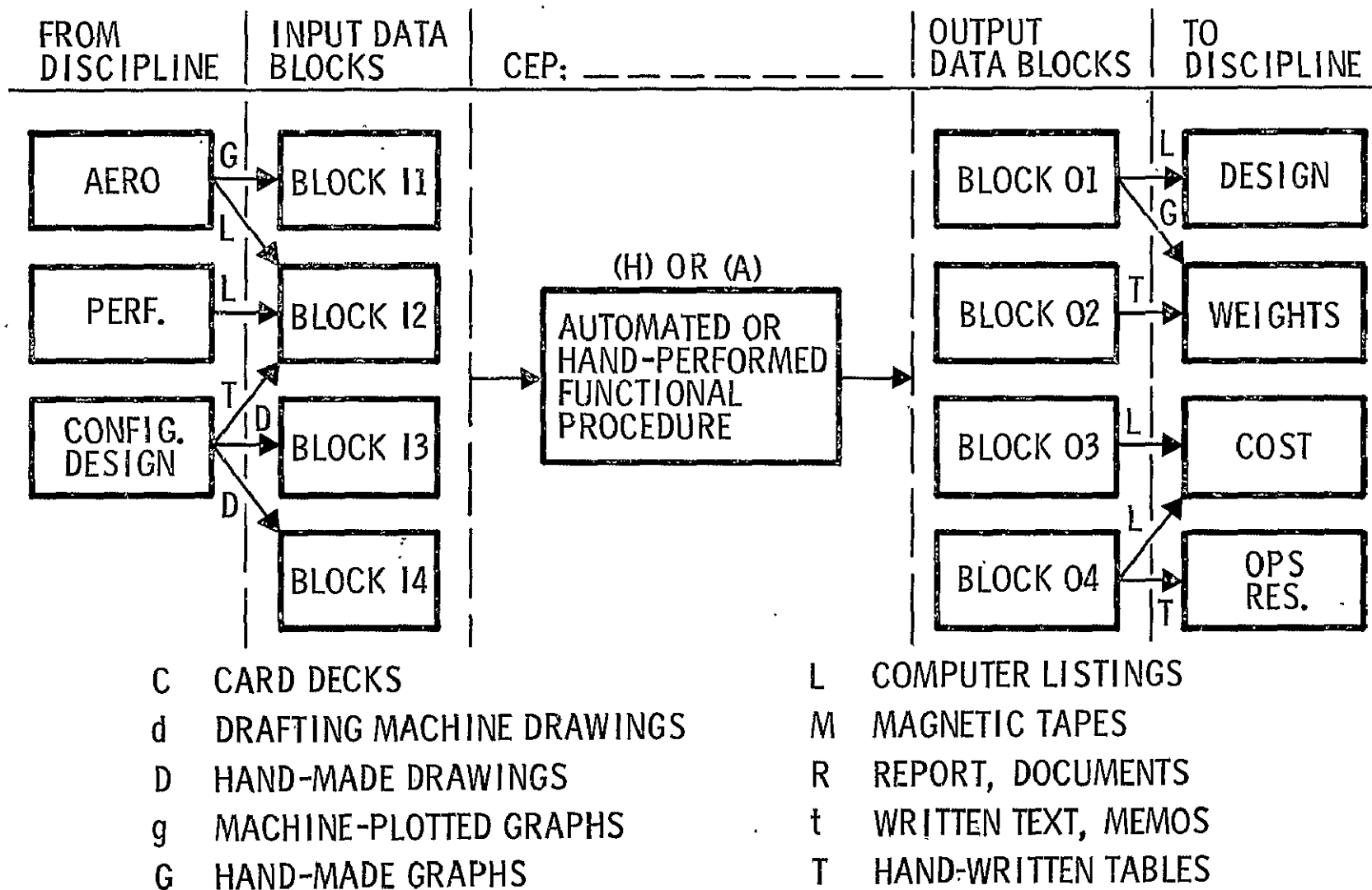


Figure 3-3. Functional CEP Flow Chart Form

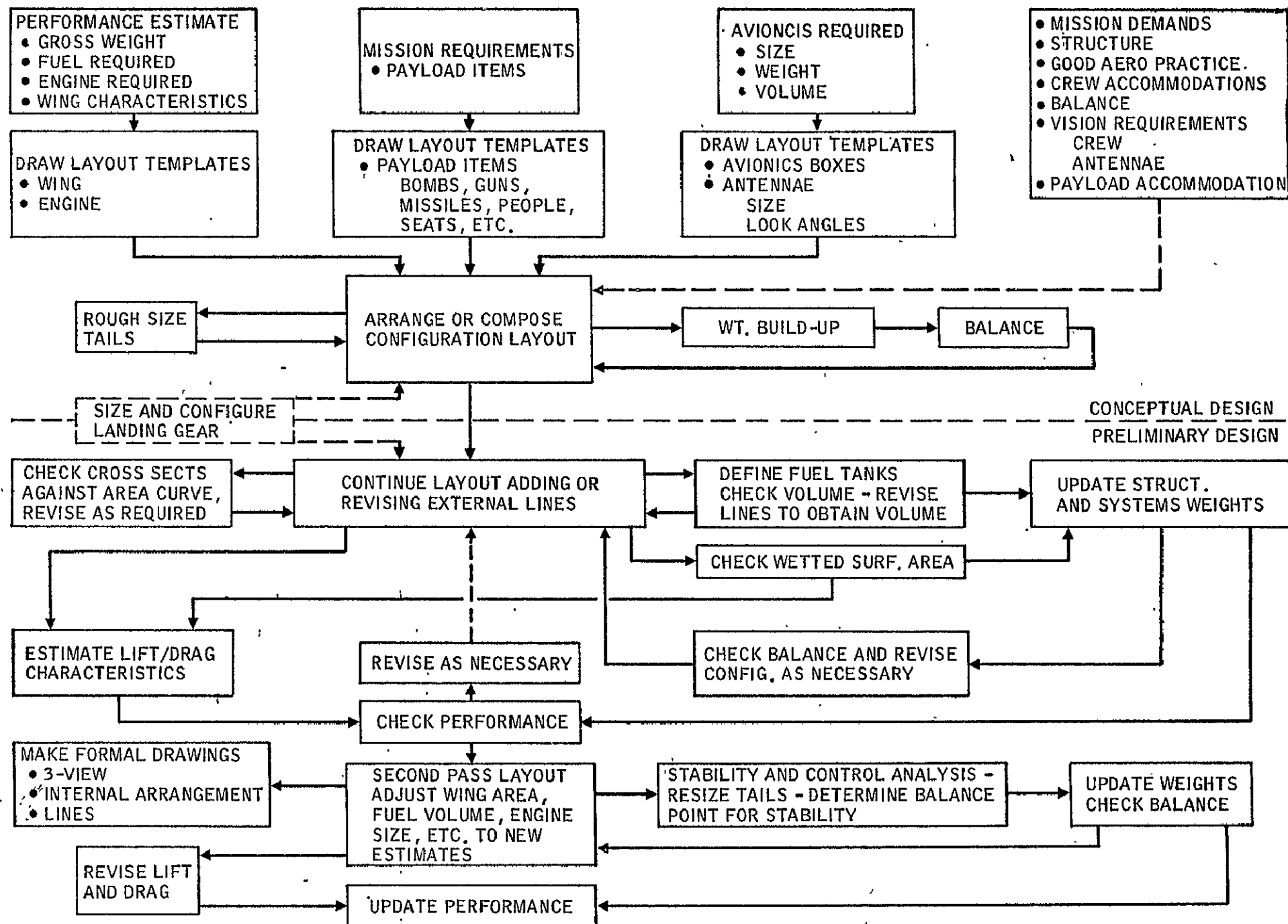


Figure 3-4. Configuration Design Process

TABLE 3-1. CONFIGURATION DESIGN CEP'S AND COMPUTER PROGRAMS

TASKS	CEP	Design Phase		
		C	PD	DD
Develop Layouts of Concepts and Basic Design Data	CD1	x		
Parametric Evaluation of Configuration Concept	CD2	x		
Initial Configuration Layouts	CD3	x		
Perform Risk Assessment	CD4	x		
Develop Layouts for Trade Studies	CD5	x		
Selected Configuration Layouts	CD6	x		
Perform Configuration Control Studies	CD7		x	
Provide Concept Configuration Description	CD8		x	
Final Configuration Control Studies	CD9		x	
Configuration Design Studies	CD10	x	x	
<u>COMPUTER PROGRAMS</u>				
Wings, Tails, Airfoil Surfaces:		x	x	
Various lines programs for fixed and variable sweep wings, fixed and all movable tails, canards, etc.				
Input: Area, aspect ratio, taper ratio, sweep, airfoil ordinates, camber ordinates, twist, pivot pin location and angle.				
Output: Planview and front of surface element lines, section cuts through surface spanwise, chordwise, or at any skewed angle, print out of cross-sectional area and surface arc length or wetted surface areas.				
Control Surfaces & High Lift Devices		x	x	
Input: Planview and front view location of hinge lines, shape dimensions and ordinates of surfaces such as flap, vanes, slats, ailerons, etc., and angle of rotation or movement.				
Output: Planview, front view, and cross section cuts through the surfaces at prescribed rotated or translated conditions.				

TABLE 3-1. CONFIGURATION DESIGN CEP'S AND COMPUTER PROGRAMS (CONT'D)

COMPUTER PROGRAMS	CEP	Design Phase		
		C	PD	DD
Fuselages, Nacelles, Bodies, etc. Various programs to describe the surface lines with real or pseudo polyconic surface description. Input: Bay start and end stations, points and slopes for the control lines (five for each polyconic surface), points and slopes for the cross section area curve (if the area curve is to control the shape), station to be cut. Output: Planview and side view of all control lines and cross section cuts at prescribed stations, print-out of all surface ordinates, cross section area and arc-lengths or wetted surface area.		x	x	
Inlets and Ducts Input: Inlet throat shape and size, engine compressor face diameter, center line of duct, and flow cross sectional area distribution from throat to compressor face. Output: Duct lines, planview, side view and cross section cuts at prescribed stations, cross-sectional area distribution, arc lengths or wetted duct surface area, and print-out of all point coordinates.		x	x	

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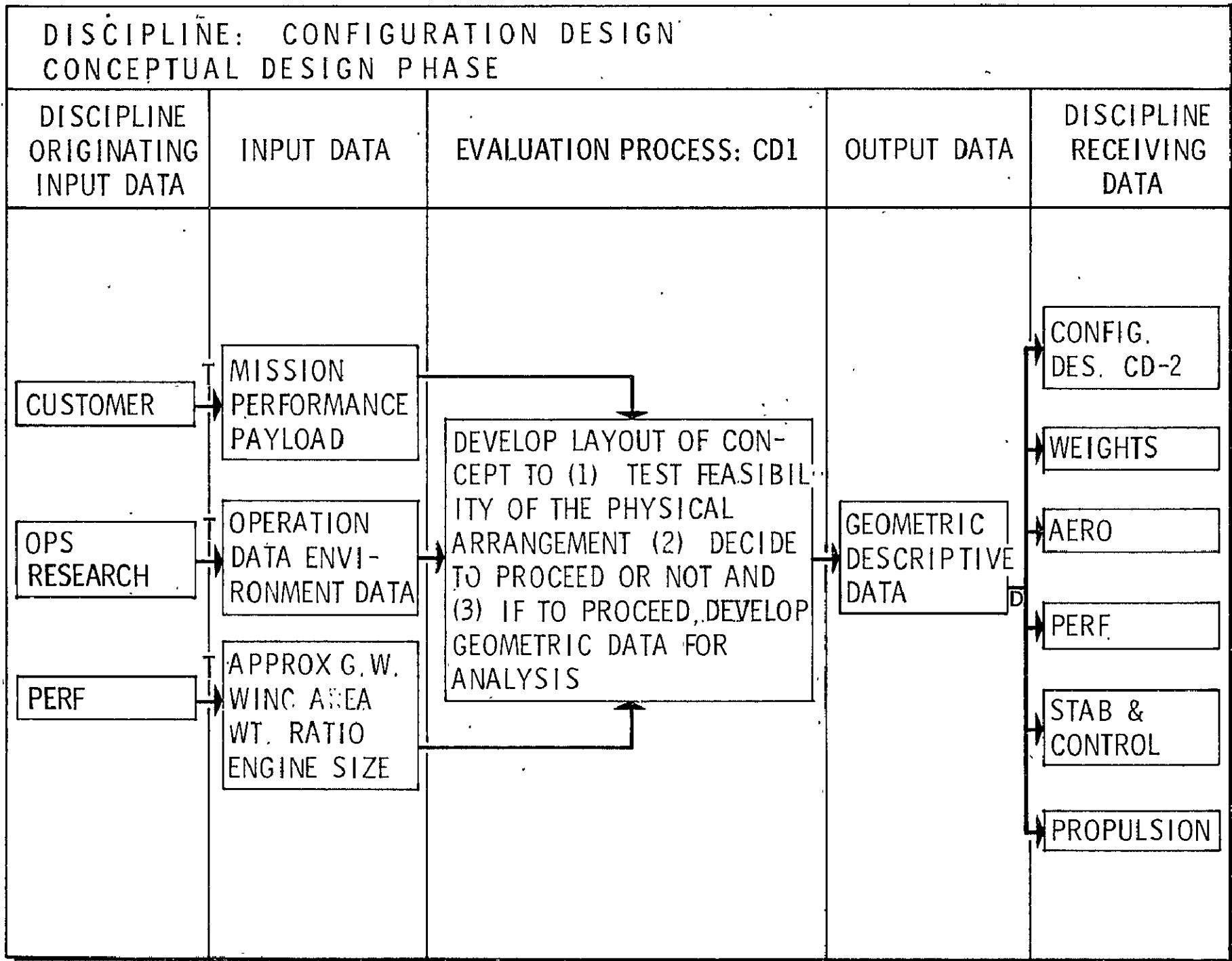


Figure 3-5. Concept Layout and Basic Design Data Development

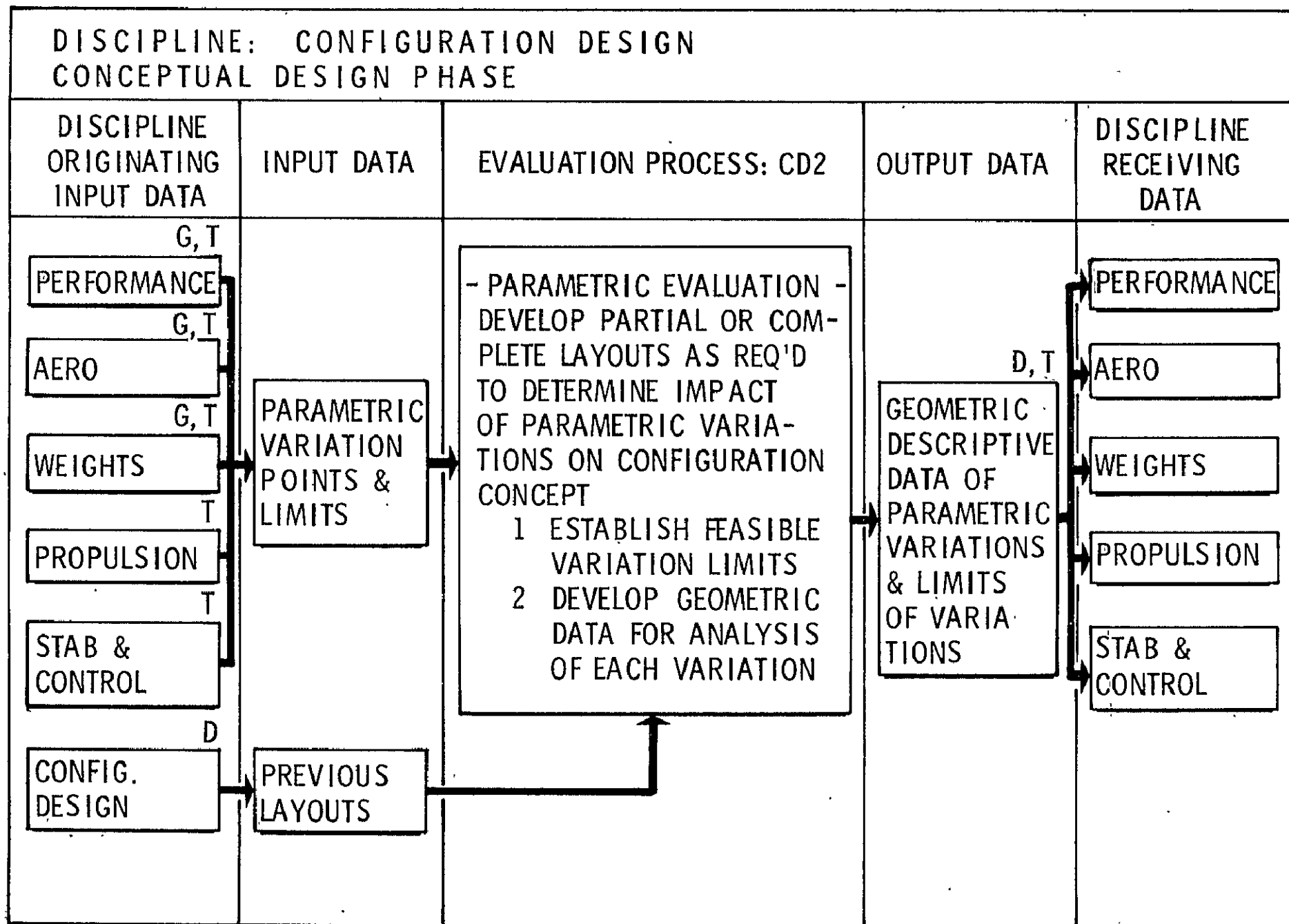


Figure 3-6. Parametric Configuration Concept Evaluation,

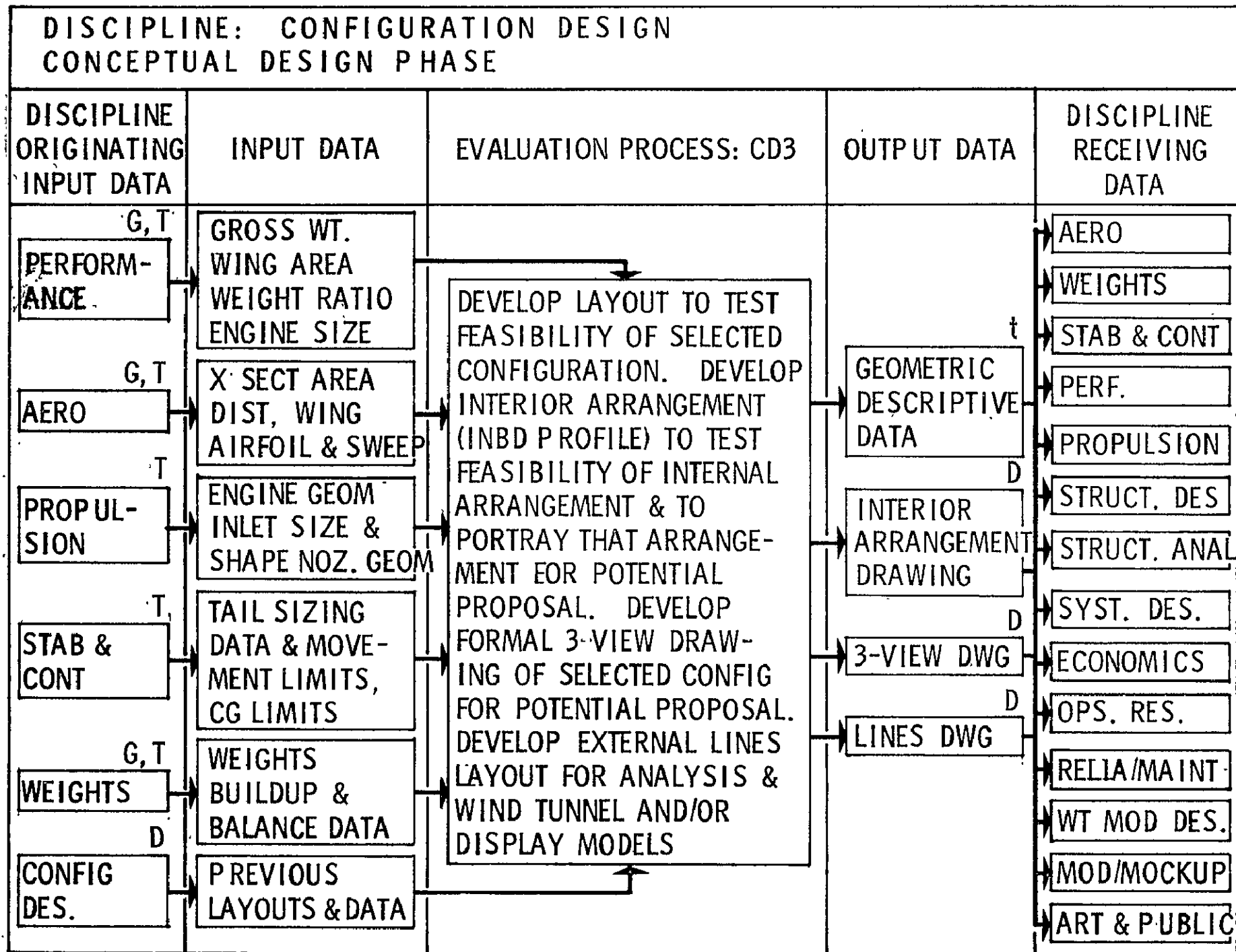


Figure 3-7. Initial Configuration Layout

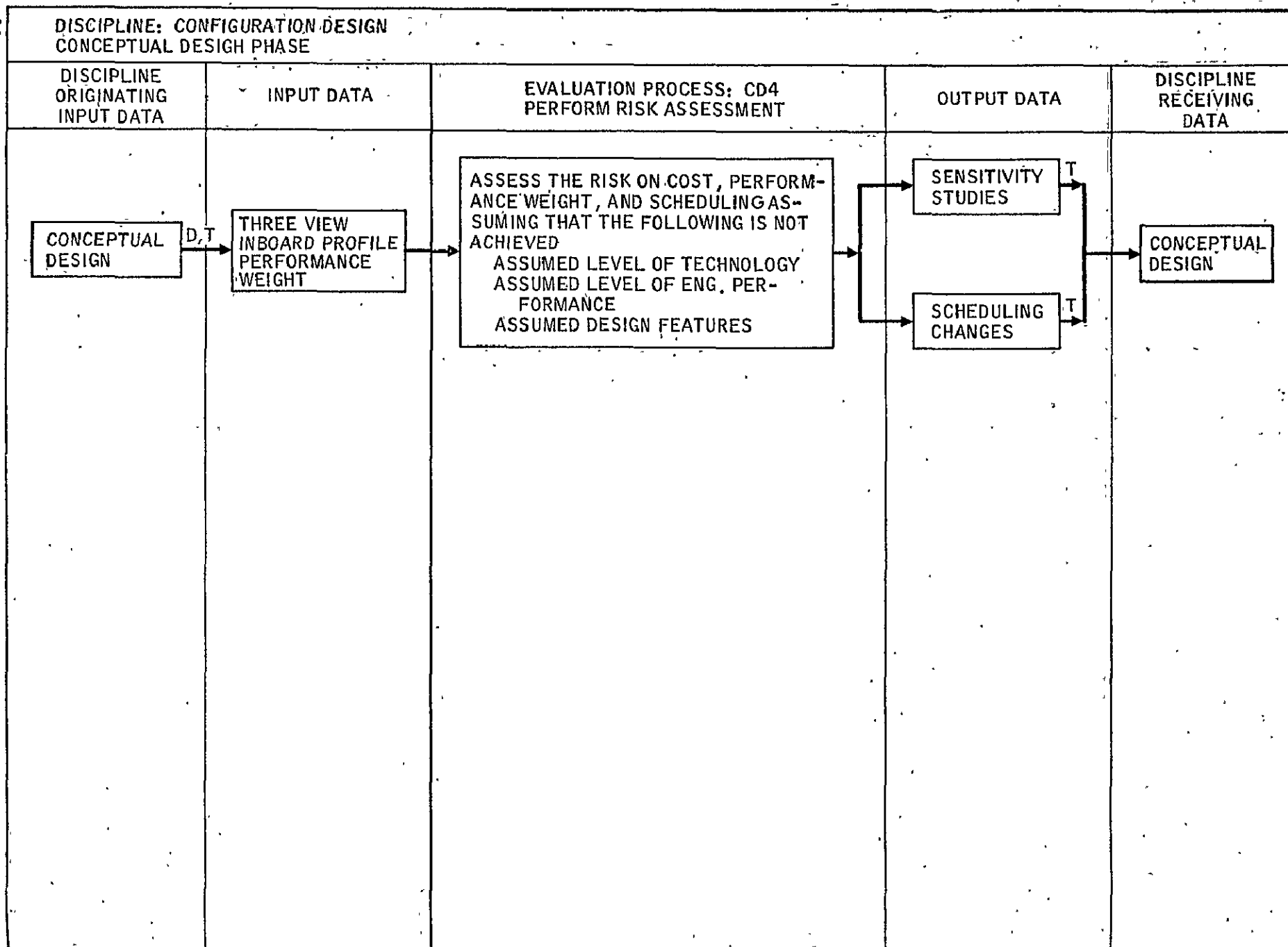


Figure 3-8. Risk Assessment

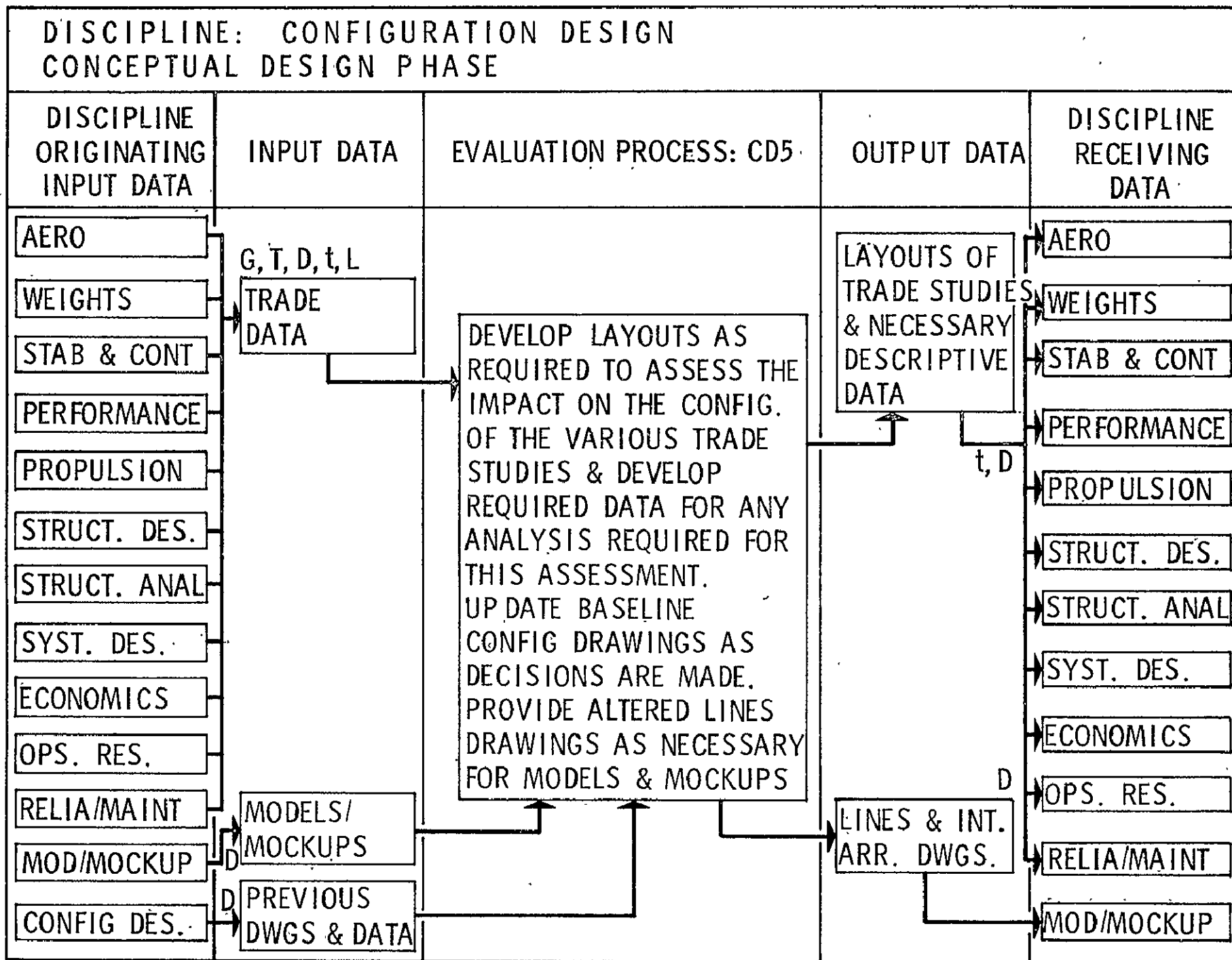
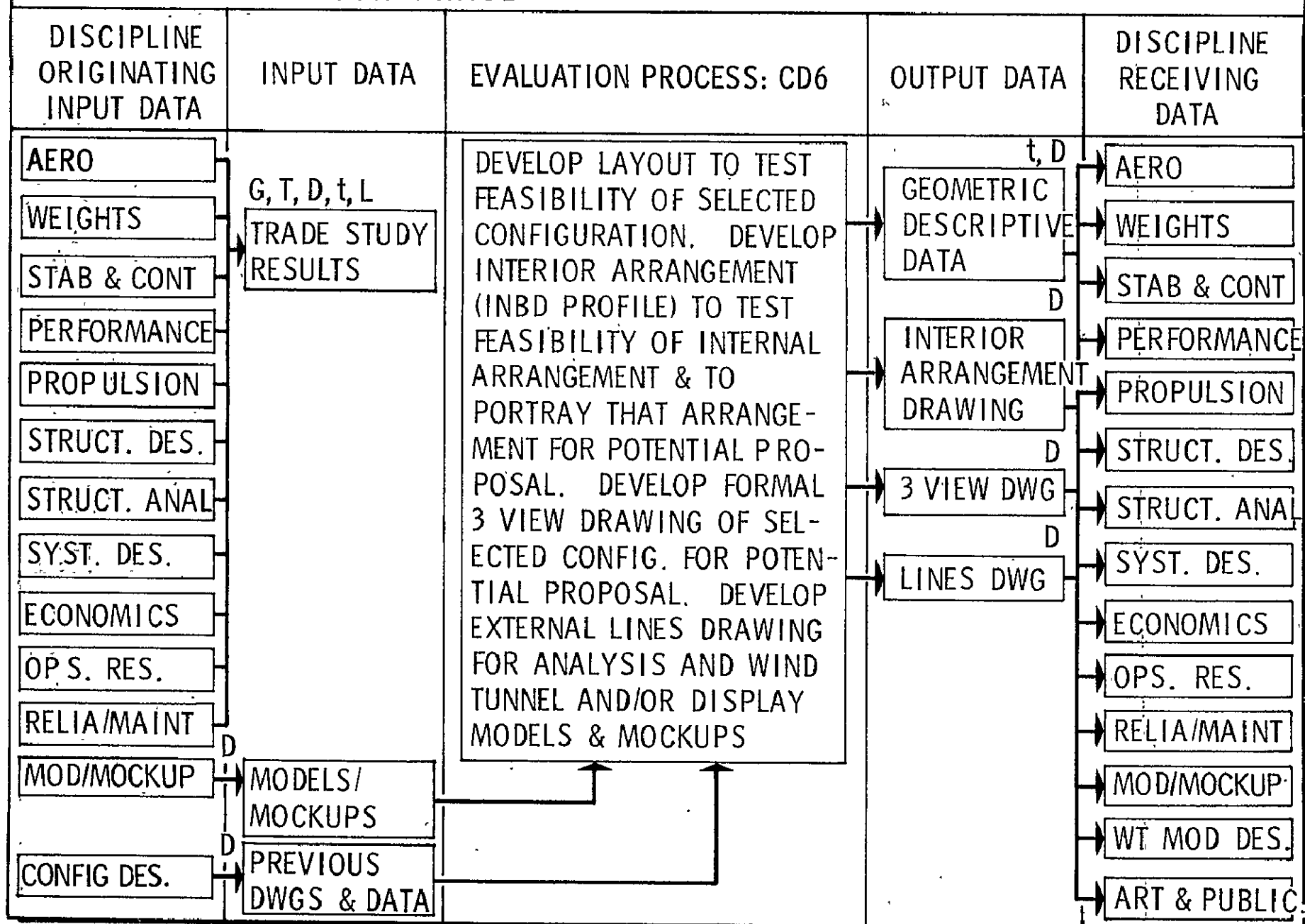


Figure 3-9. Trade Study Layouts

DISCIPLINE: CONFIGURATION DESIGN CONCEPTUAL DESIGN PHASE



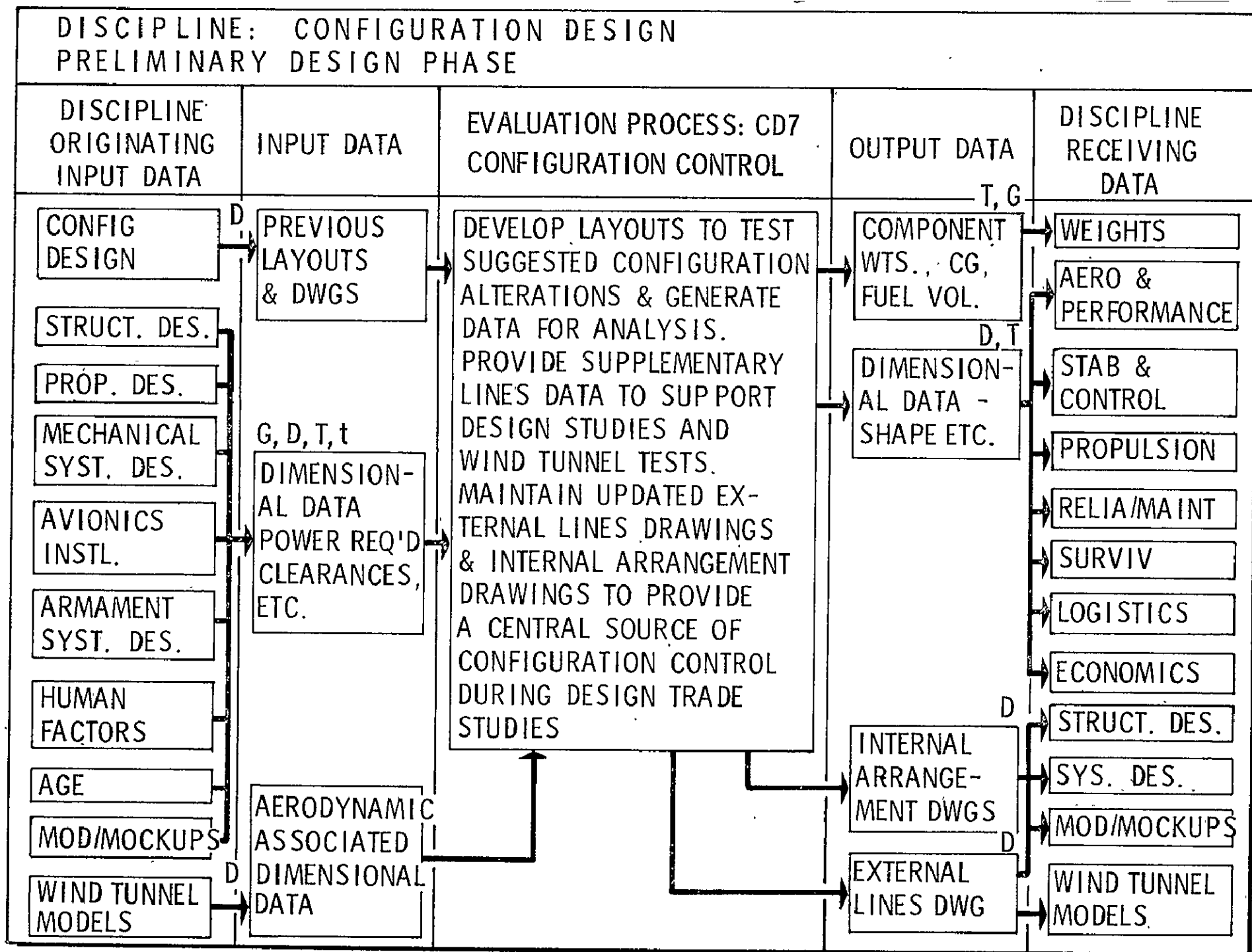
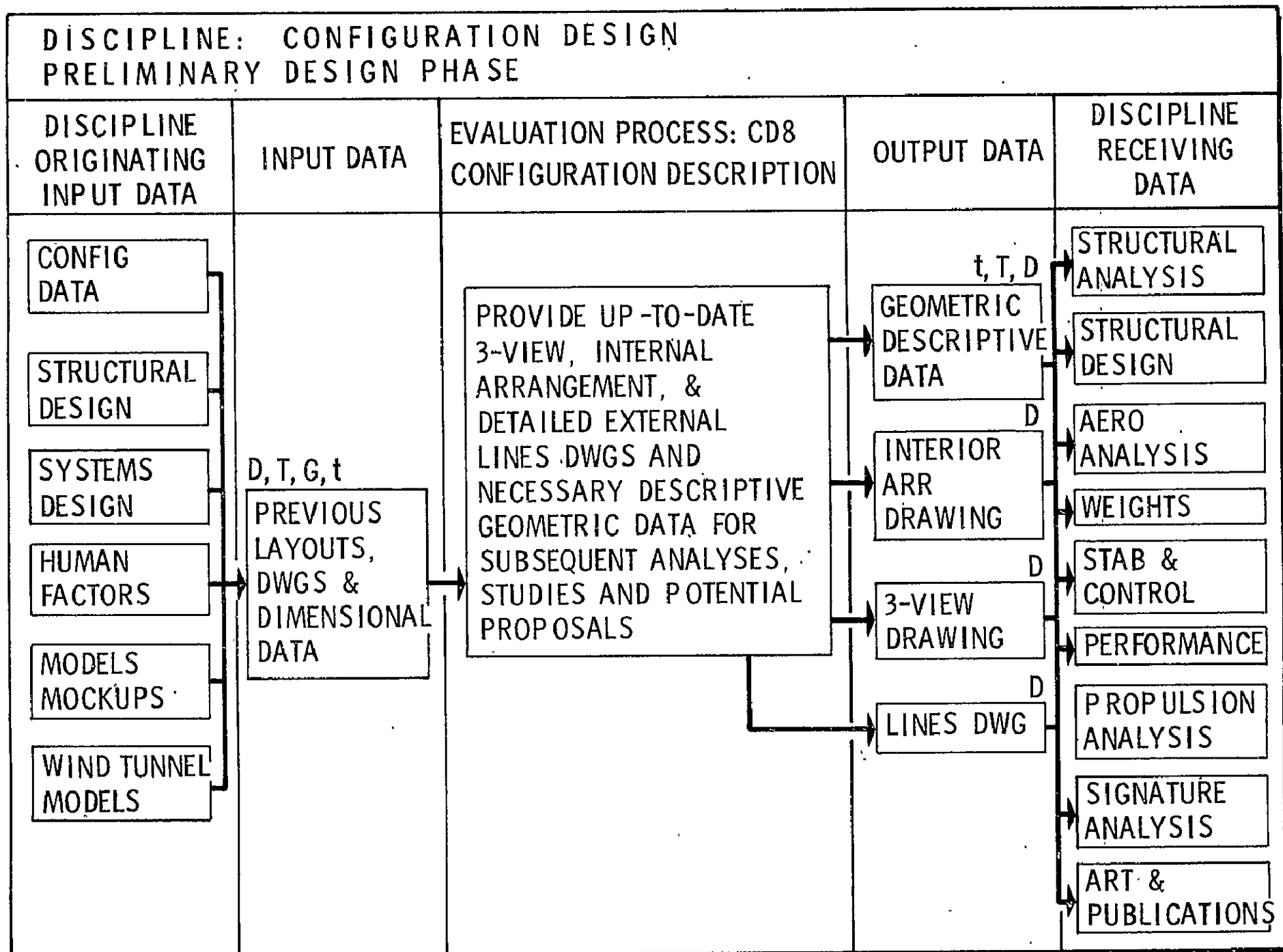


Figure 3-11. Configuration Control Studies



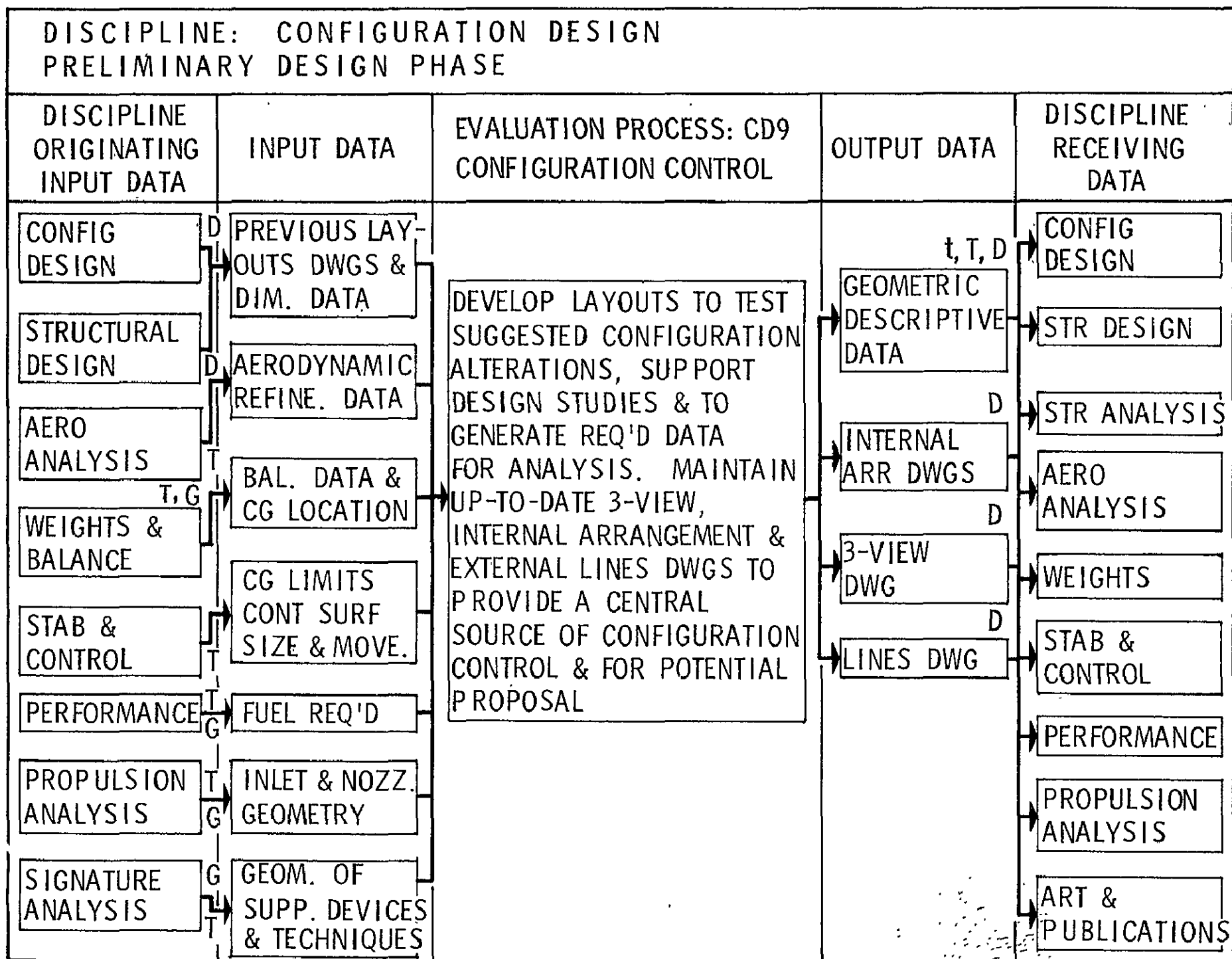


Figure 3-13. Final Configuration Control

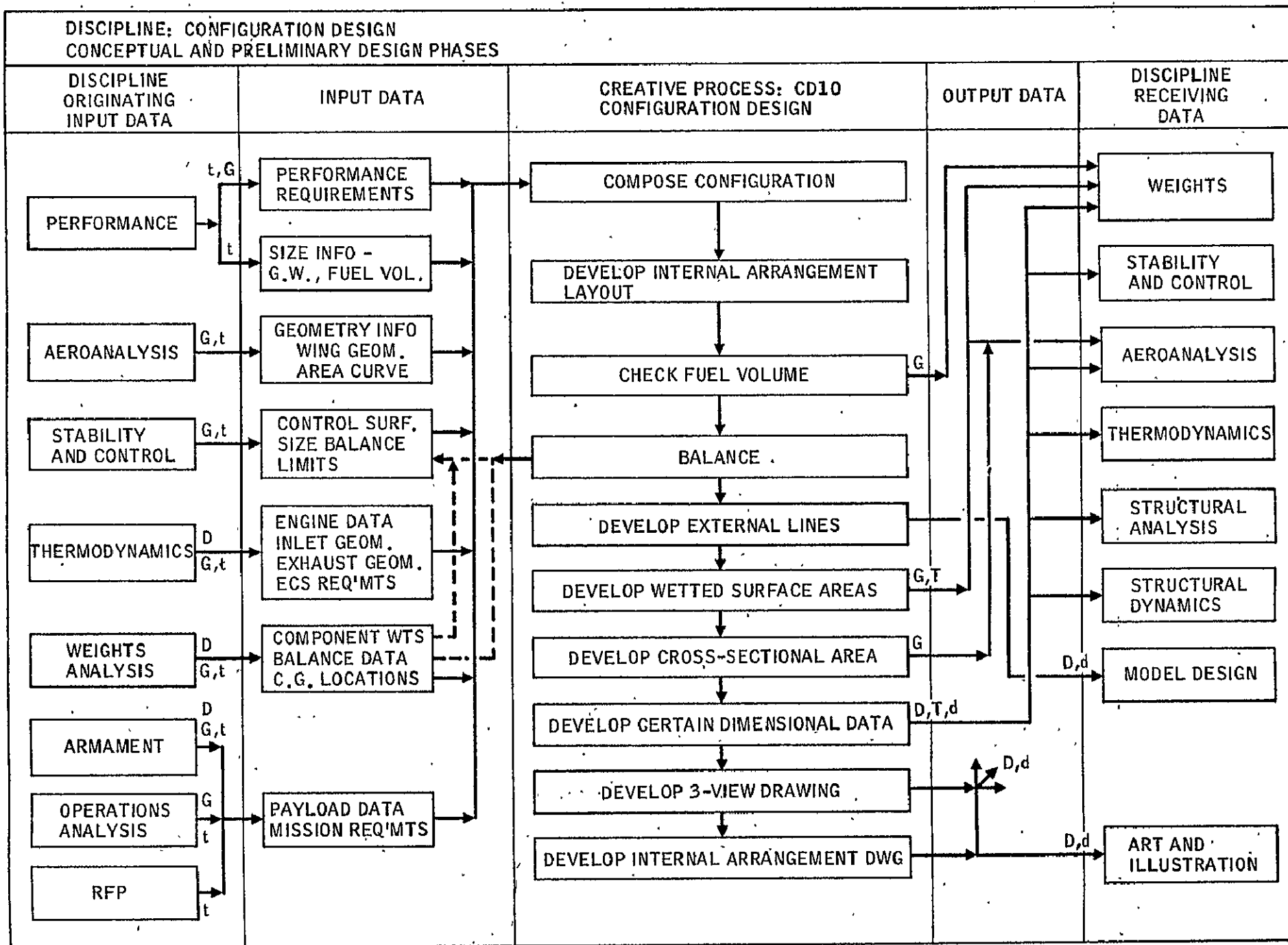


TABLE 3-2. AERODYNAMICS CEP'S AND COMPUTER PROGRAMS

TASKS	CEP	Design Phase		
		C	PD	DD
Point design drag and lift analysis		x	x	x
Parametric trade studies		x	x	
Trim drag analysis			x	x
Low speed takeoff and landing aerodynamic analysis		x	x	x
Buffet analysis			x	x
Sonic boom analysis			x	x
Wave drag analysis and minimization		x	x	x
Detailed drag analysis of aircraft roughness and protuberances				x
Airframe-propulsion integration (inlet, diverter, nozzle)			x	x
Wind tunnel planning and test monitoring			x	x
Wind tunnel data analysis			x	x
Wing detailed design			x	x
High lift system design				x
Wing load analysis			x	x
External store load analysis				x
External surface load analysis				x
Wind tunnel load data reduction			x	x

TABLE 3-2. AERODYNAMICS CEP'S AND COMPUTER PROGRAMS (CONT'D)

COMPUTER PROGRAMS		CEP	Design Phase		
			C	PD	DD
P5401	Combat Aircraft Synthesis Program		x	x	
SPADE	Conceptual design aircraft synthesis program. Computes geometry, aerodynamics, weights and performance.		x		
AA20	Drag Calculation Procedure		x		
AeroModule	Aerodynamic characteristics (lift, drag, etc.) of aircraft either as perturbations of known characteristics or as the result of internal methods.			x	
NASA-Carlson	Determines supersonic pressure distributions and loads on wings or arbitrary planform and warped surface or wing/body/tail combinations.			x	x
NASA-Friedman	Sonic boom propagation through a non-homogenous atmosphere with considerations of acceleration and maneuvering.			x	x
NASA-Carlson	Far field, sonic boom calculations for specific aircraft based on area rule and lift distribution.			x	x
NASA-Harris	Calculates zero lift wave drag of arbitrary aircraft and optimizes configuration for minimum wave drag.			x	x
Douglas-Cebeci and Smith	2-D axisymmetric laminar/turbulent boundary layer parameters.			x	x
NASA-Charmichael Woodward	Superposition of singularities over finite elements to represent arbitrary 3-D wing-body-tail combinations in subsonic and supersonic flow.			x	x
Wing Design	Wing design and analysis including induced drag, isobar mapping, and integrated pressure drag. Uses linear superposition of Charmichael or Woodward procedure results.			x	x

TABLE 3-2. AERODYNAMICS CEP'S AND COMPUTER PROGRAMS (CONT'D)

<u>COMPUTER PROGRAMS</u>		CEP	Design Phase		
			C	PD	DD
Douglas-Gentry	Hypersonic Arbitrary Body Program			x	x
Vortex Lattice	Vortex lattice method to represent the potential lifting flow about arbitrary, multi-element, 3-D cambered surfaces.				x
Distributed Singularities	2-D inviscid and viscous flow about multi-element airfoils up to maximum lift.			x	x
Non-Linear Span Load	Uses nonlinear section data to predict 3-D characteristics of wings with high lift devices. An iterative procedure is used to obtain the circulation along the lifting line.			x	x
Powered Lift	Empirical prediction method for generalized powered-lift applications.			x	x

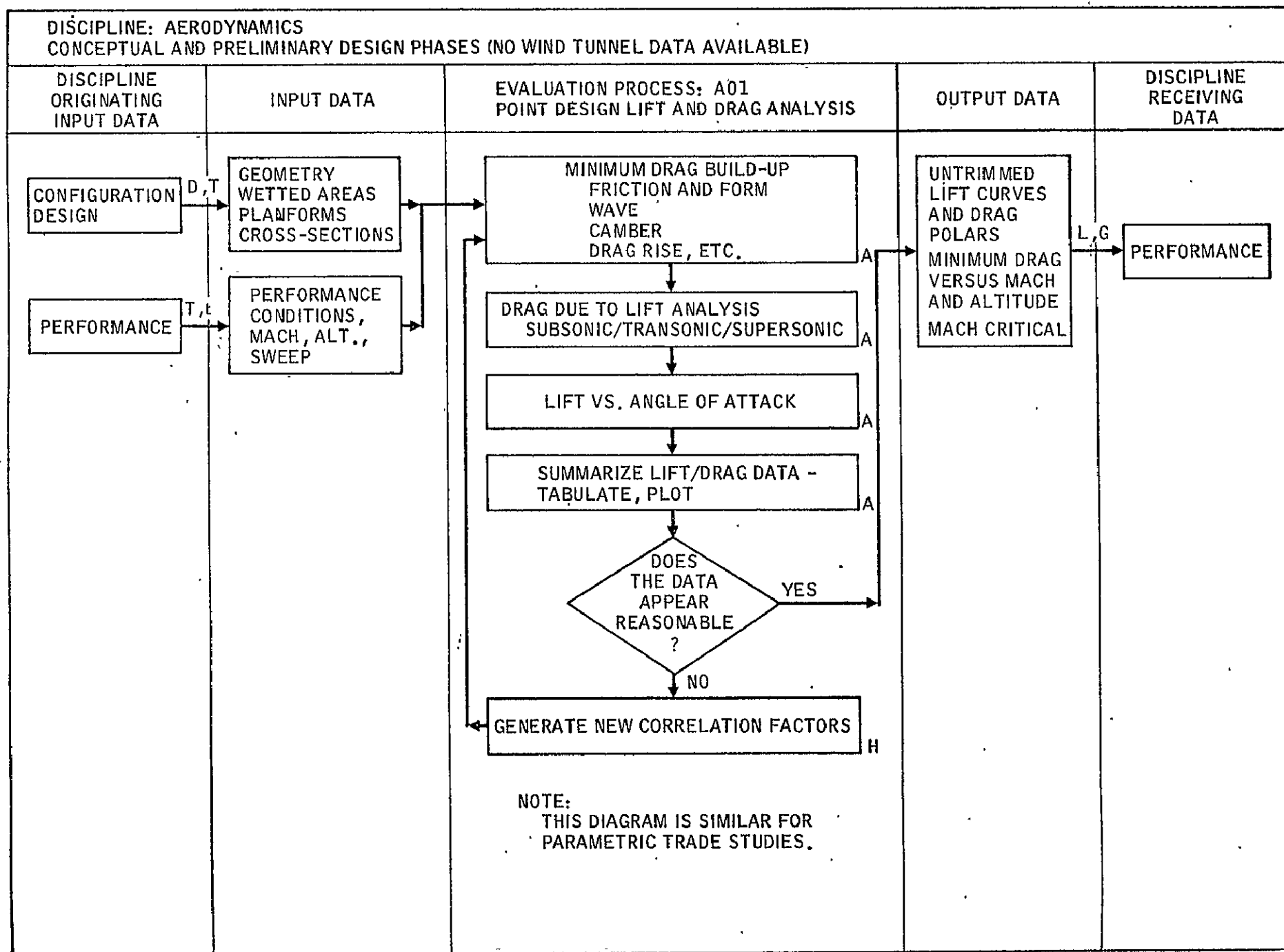


Figure 3.15 Point Design Lift and Drag Analysis (No Wind Tunnel Data)

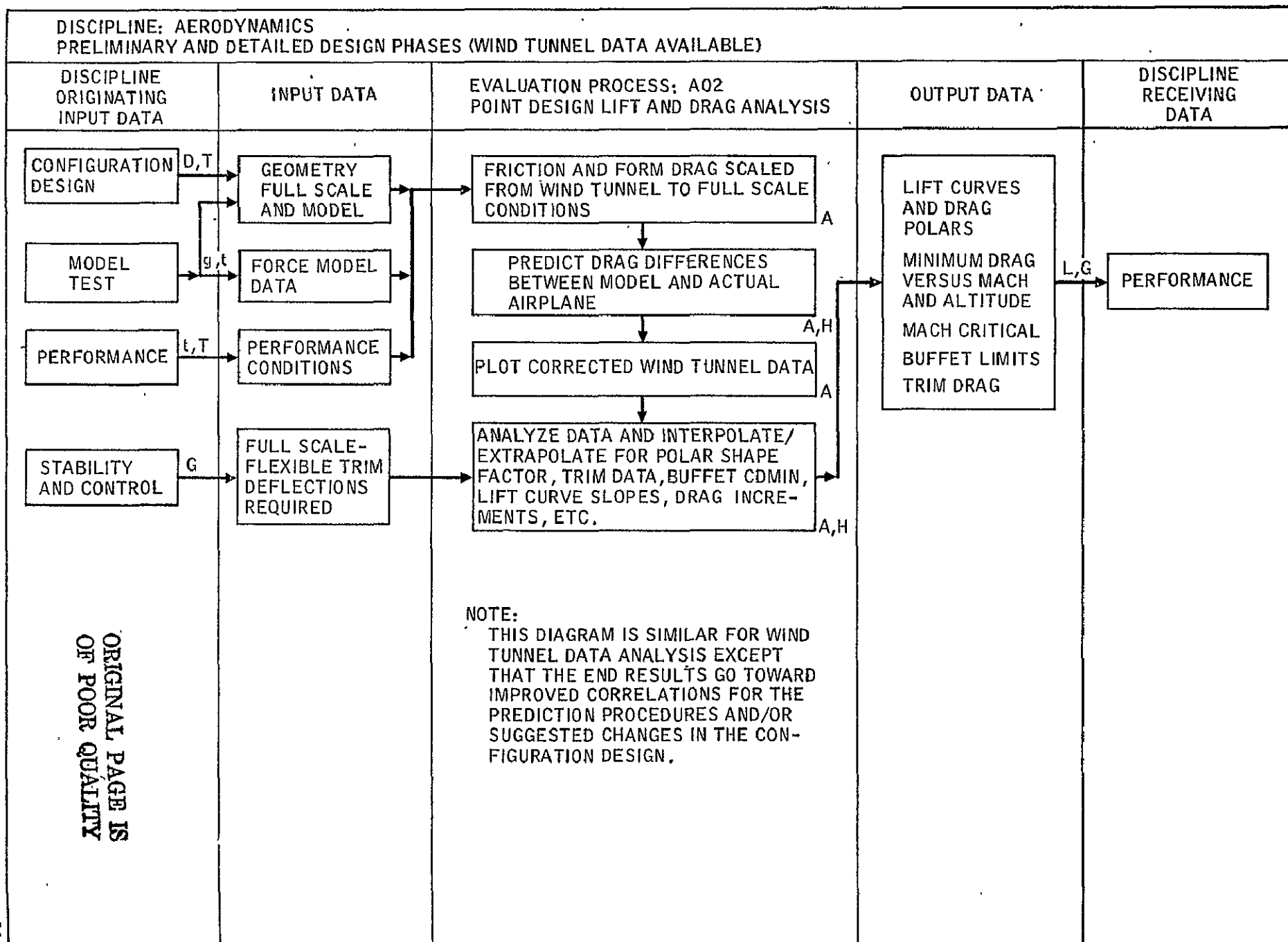


Figure 3-16. Point Design Lift and Drag Analysis (With Wind Tunnel Data)

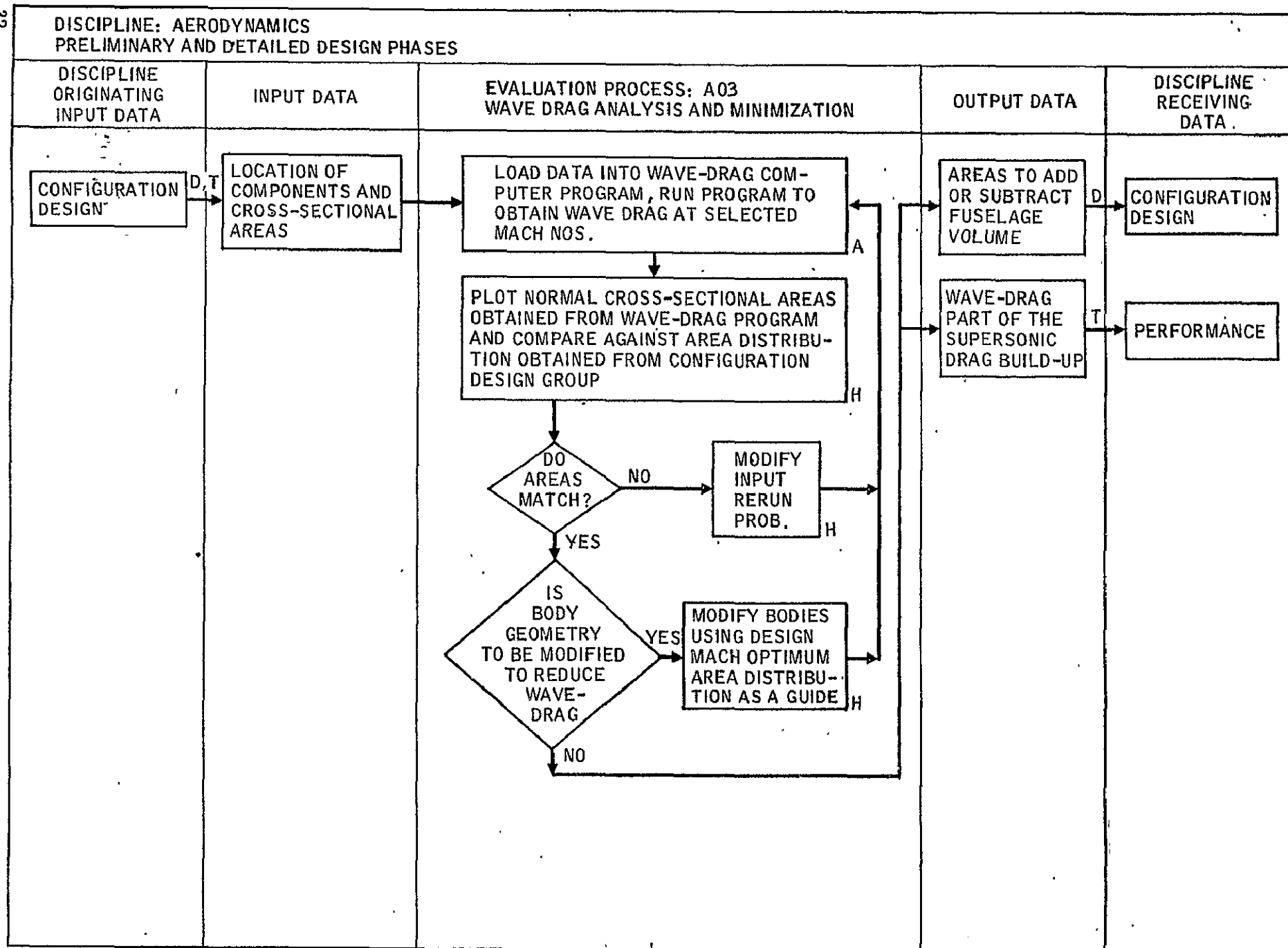


Figure 3-17: Wave Drag Analysis and Optimization

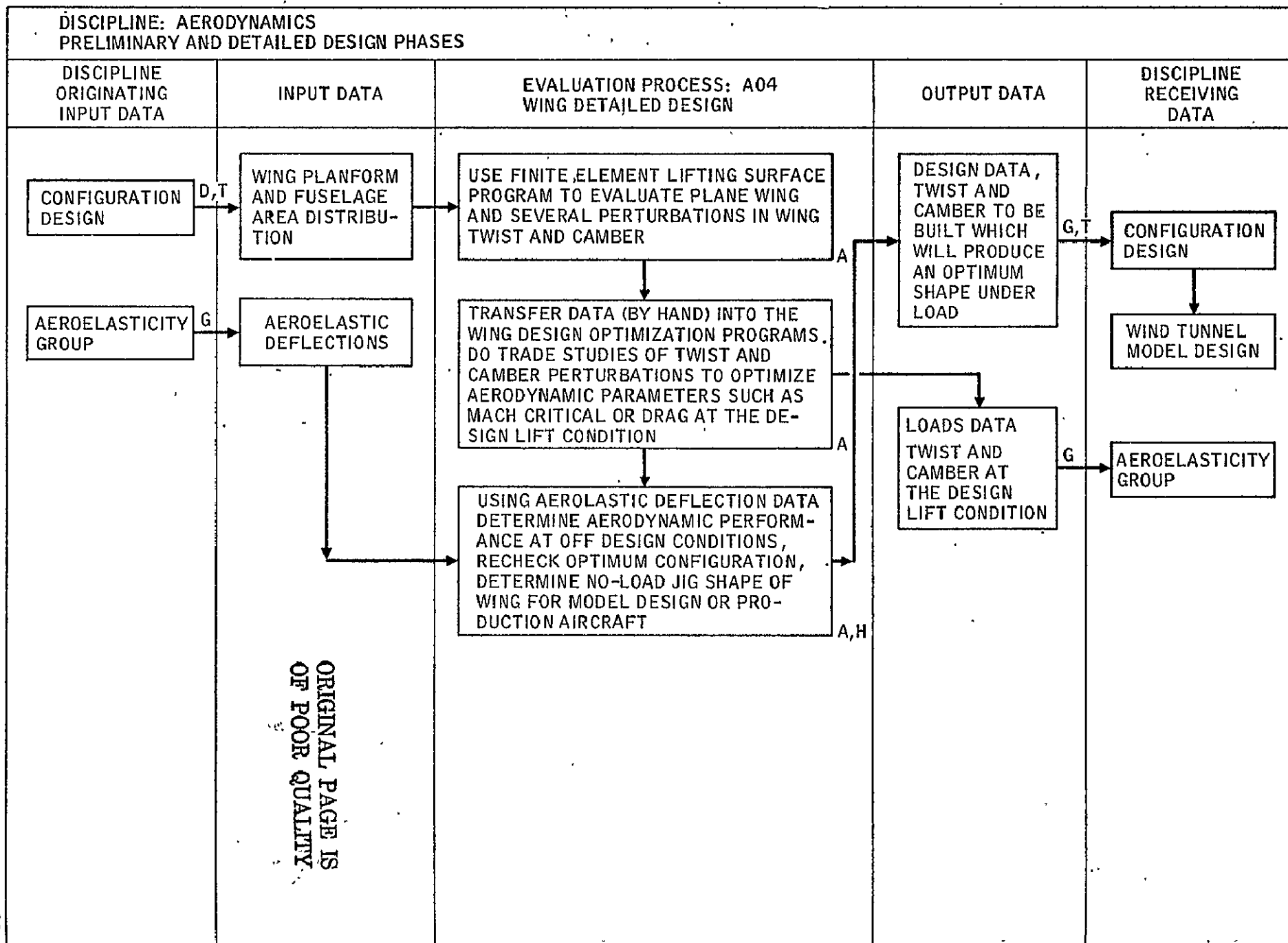
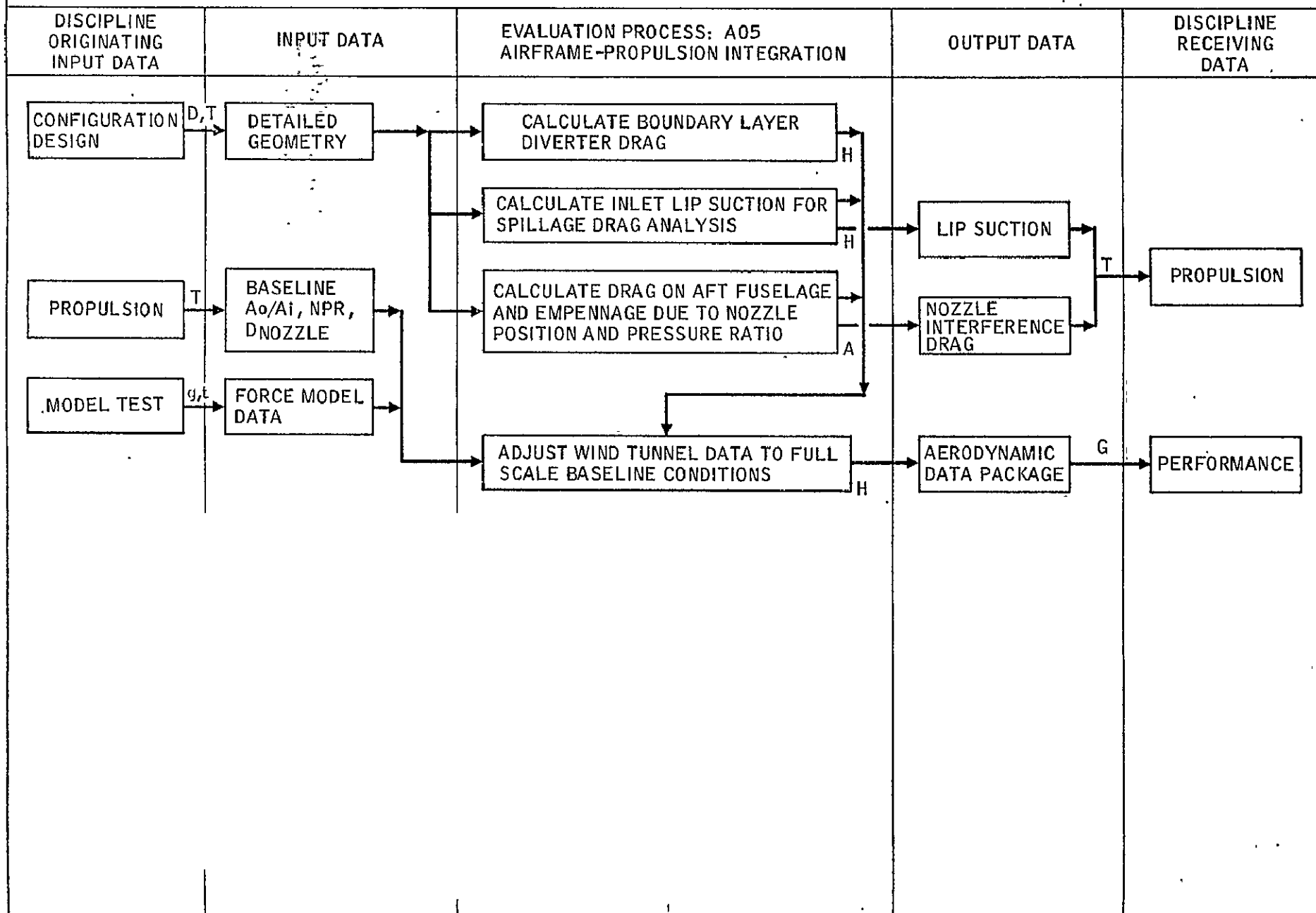


Figure 3-18. Wing Detailed Design

DISCIPLINE: AERODYNAMICS
PRELIMINARY AND DETAILED DESIGN PHASES



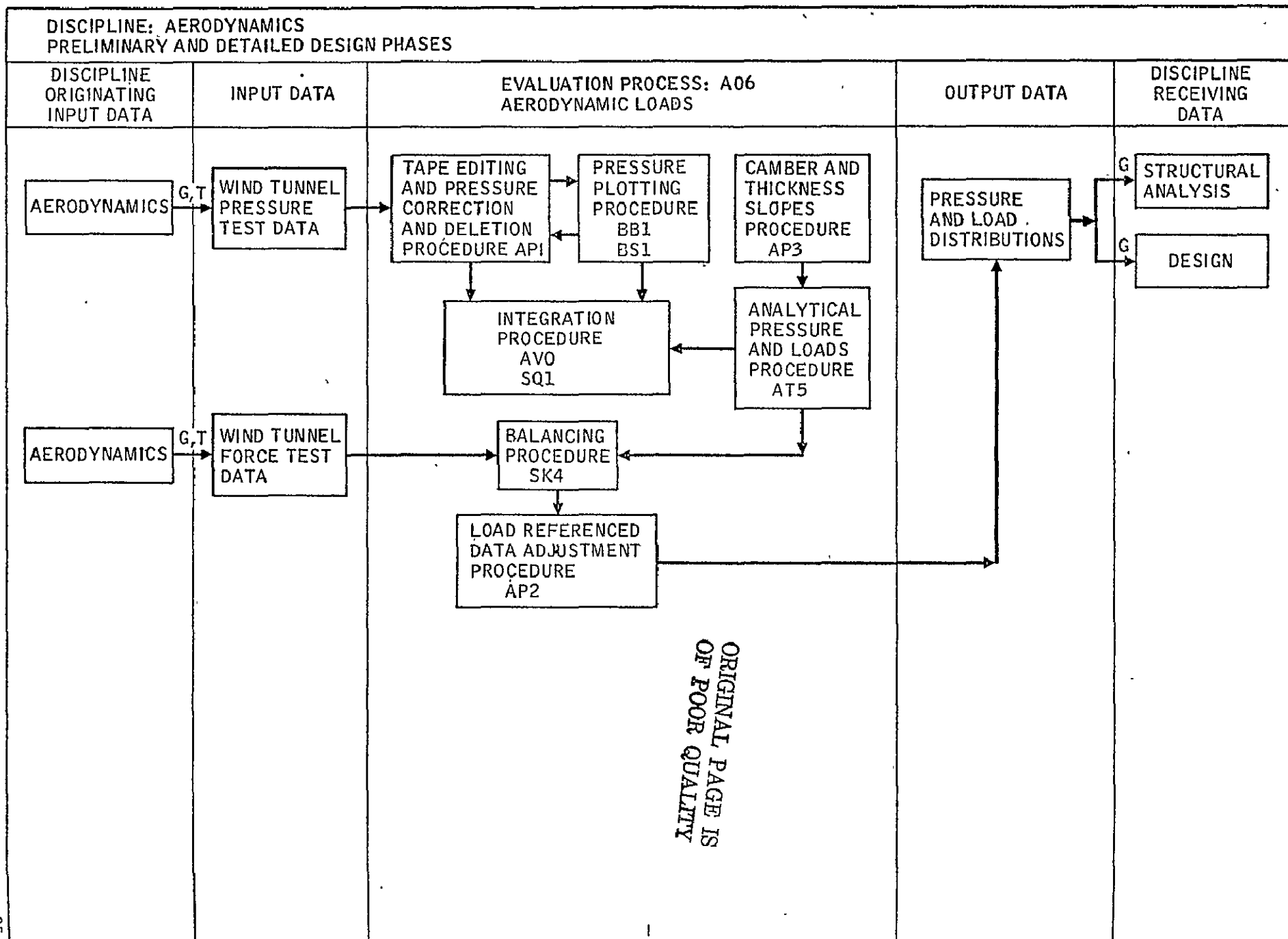


Figure 3-20. Aerodynamic Loads

TABLE 3-3. PERFORMANCE CEP'S AND COMPUTER PROGRAMS

TASKS	CEP	Design Phase		
		C	PD	DD
Concept Selection		x		
Mission Performance Analyses				
Acceleration	PE01	x	x	x
Climb	PE02	x	x	x
Cruise and Loiter	PE03	x	x	x
Deceleration		x	x	x
Refuel		x	x	x
Combat		x	x	x
Descent		x	x	x
Mission Fuel Calculation	PE04	x	x	x
Sizing and Parametric Trade Studies	PE05			
Engine cycle, number, size, location		x	x	
Wing size, planform, section		x	x	
Mission and payload		x	x	x
Subsystems		x	x	x
Materials and structural concepts		x	x	
Flight Mechanics Simulations and Analyses	PE06			
Landing and takeoff		x	x	x
Maneuverability		x	x	x
Air-to-air combat			x	x
Terrain-following			x	x
Dynamic flight path optimization			x	x
Etc.				
Provide Summary Charts to Project Management, Systems Analysis, and Customer	PE07	x	x	x
<u>COMPUTER PROGRAMS</u>				
SYNAC	Large scale fighter aircraft synthesis program		x	
SSS-1	Space shuttle flyback system synthesis program		x	
MAPS	Mission analysis and performance system		x	x
IMP	General aircraft mission integration program		x	x

TABLE 3-3. PERFORMANCE CEP'S AND COMPUTER PROGRAMS (CONT'D)

CEP	Design Phase		
	C	PD	DD
<u>COMPUTER PROGRAMS</u> (Continued)			
LWF Mission Program, Air Vehicle Model TRAP, ATF Mission Prog.		x	x
TAPER, AC6		x	x
MACE		x	x
ATAC		x	x
GROPE		x	x
P5401	x	x	x
AA21	x		
AA33	x		
AA23	x		
AA32	x		
AA22	x		
AA34			
10/24/74 J.A. 21/10/74 7/11/74 10/24/74			

U.S. AIR FORCE
 WRIGHT-PATTERSON AIR FORCE BASE
 WRIGHT-PATTERSON AIR FORCE BASE

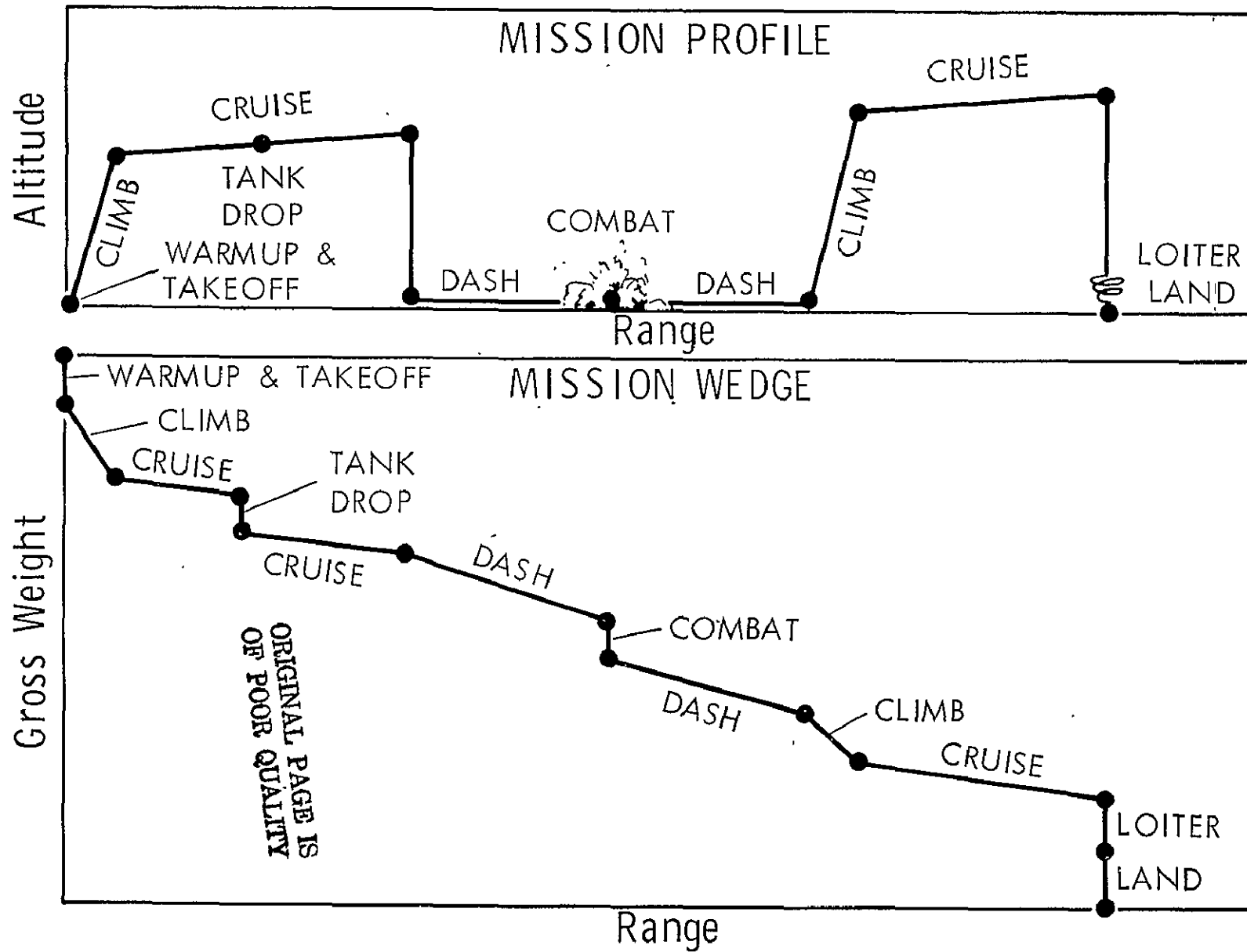
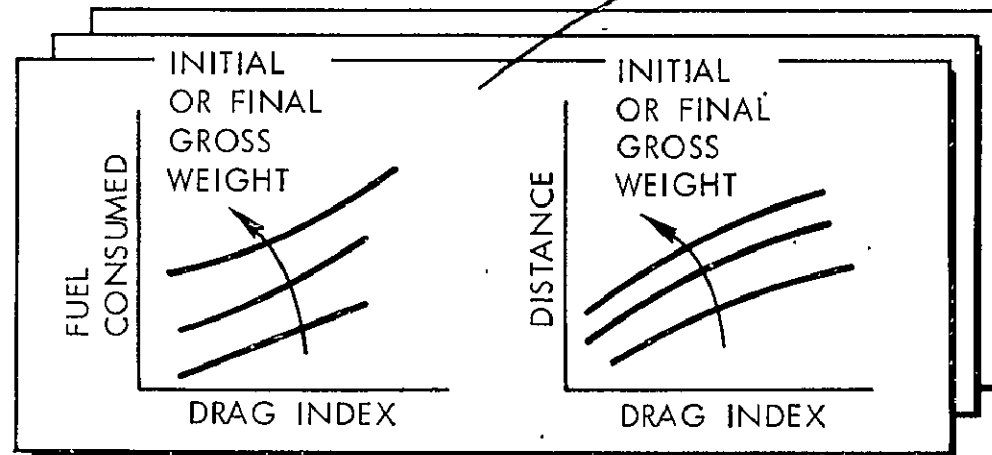


Figure 3-21. Mission Performance Analyses

- TAKEOFF
- LANDING
- DROP
- CRUISE
- DASH
- COMBAT
- LOITER
- CLIMB
- DESCENT
- ACCELERATION
- DECELERATION
- REFUEL

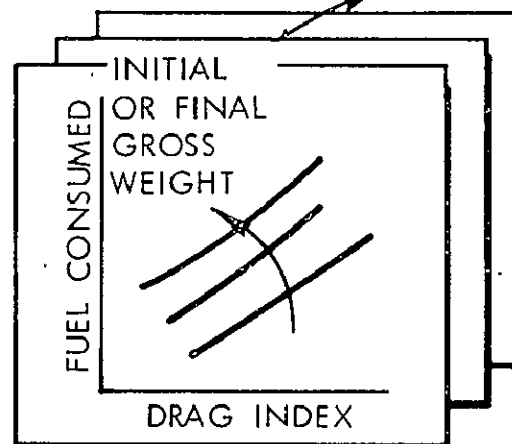
CLIMB, DESCENT, ACCEL, DECEL

Schedule



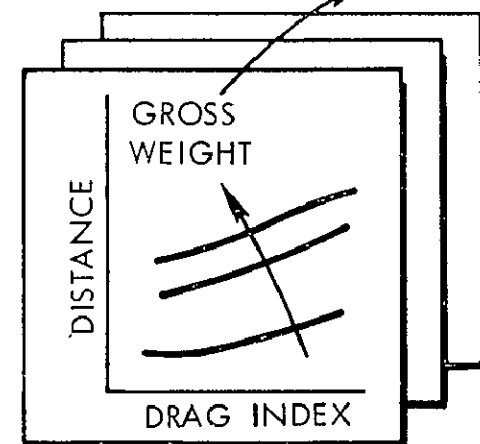
COMBAT, LOITER

Time



CRUISE, DASH

Mach



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Figure 3-22. Standard Mission Segments

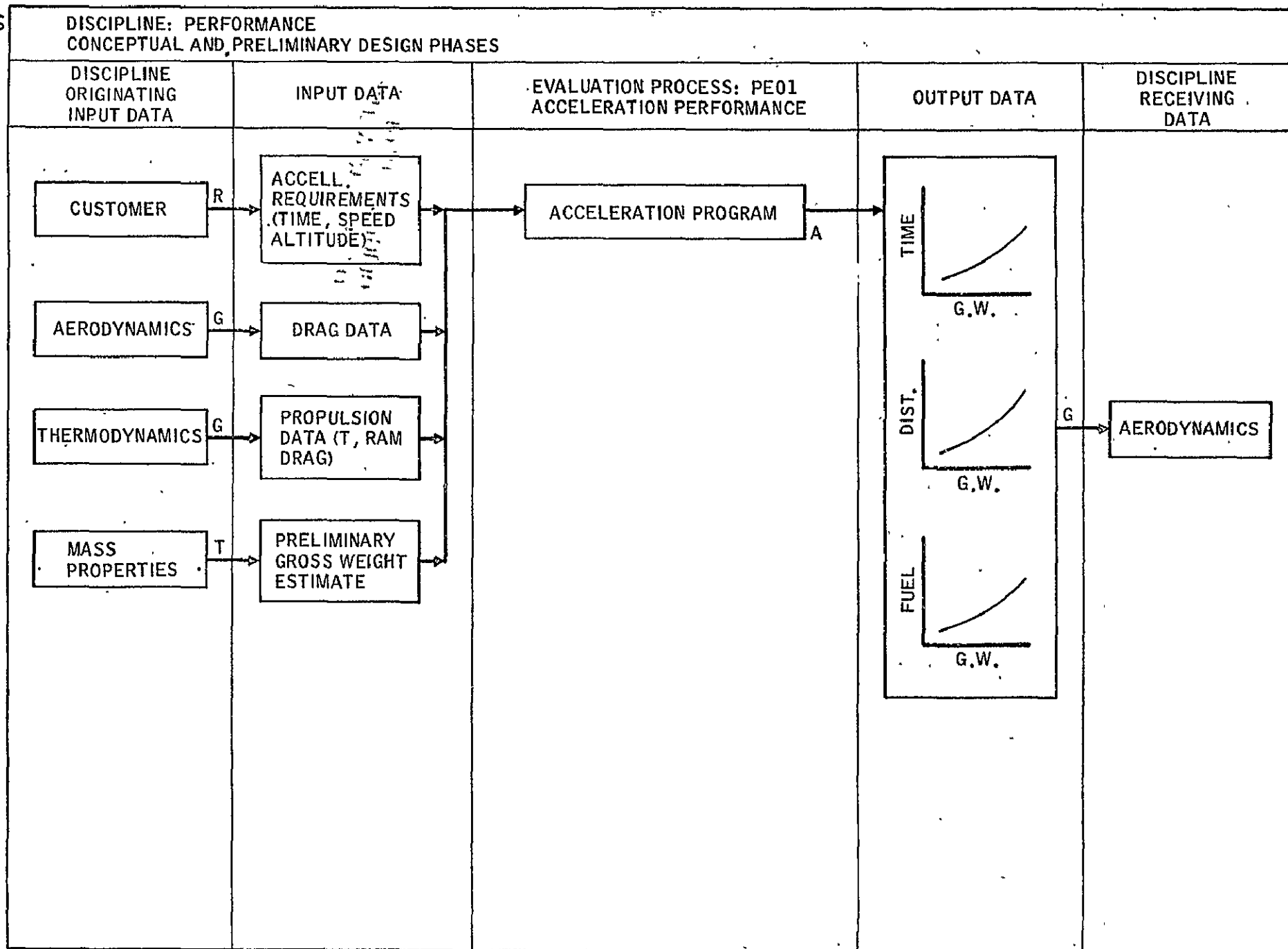


Figure 2.22 Acceleration Performance

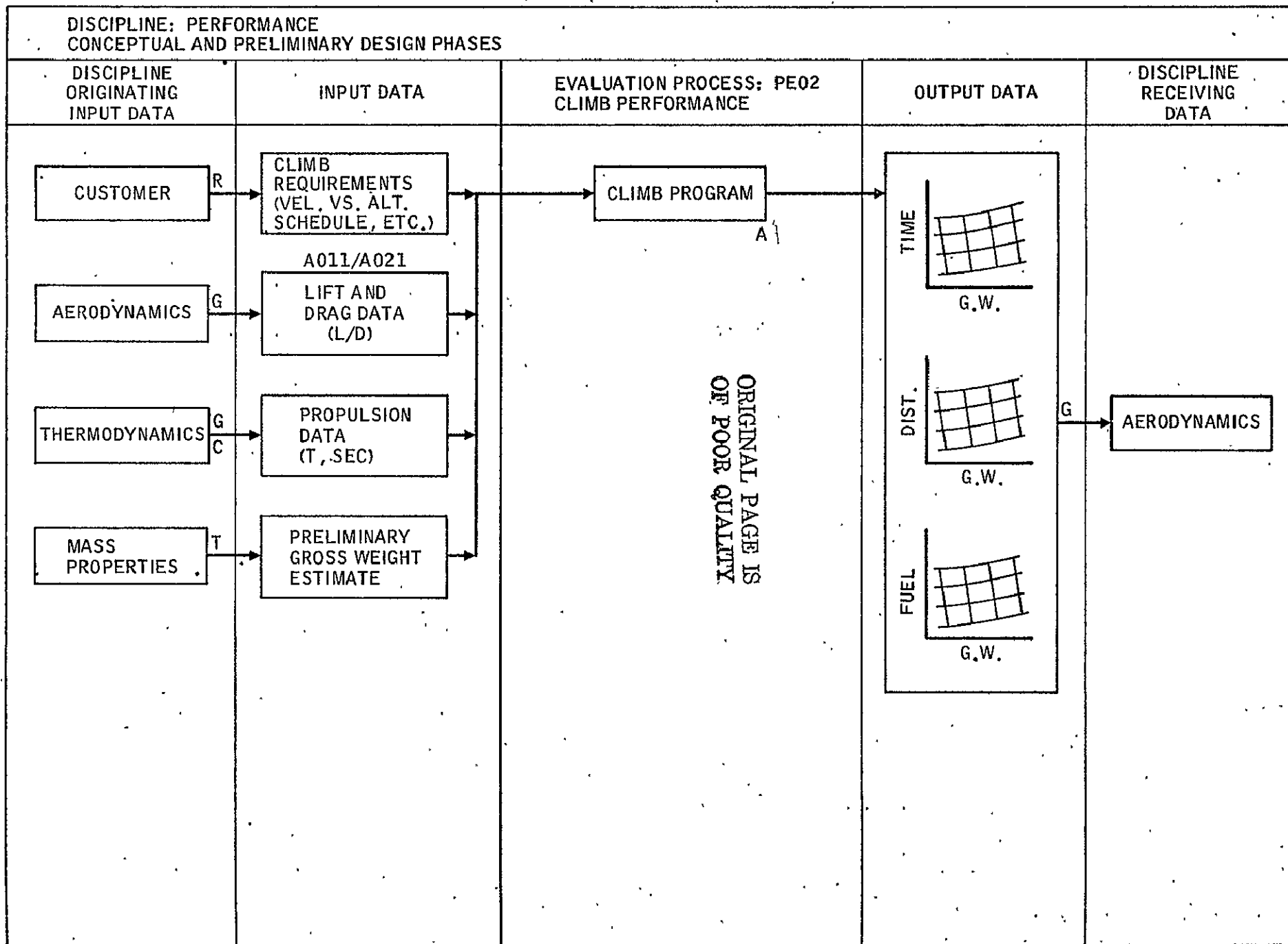
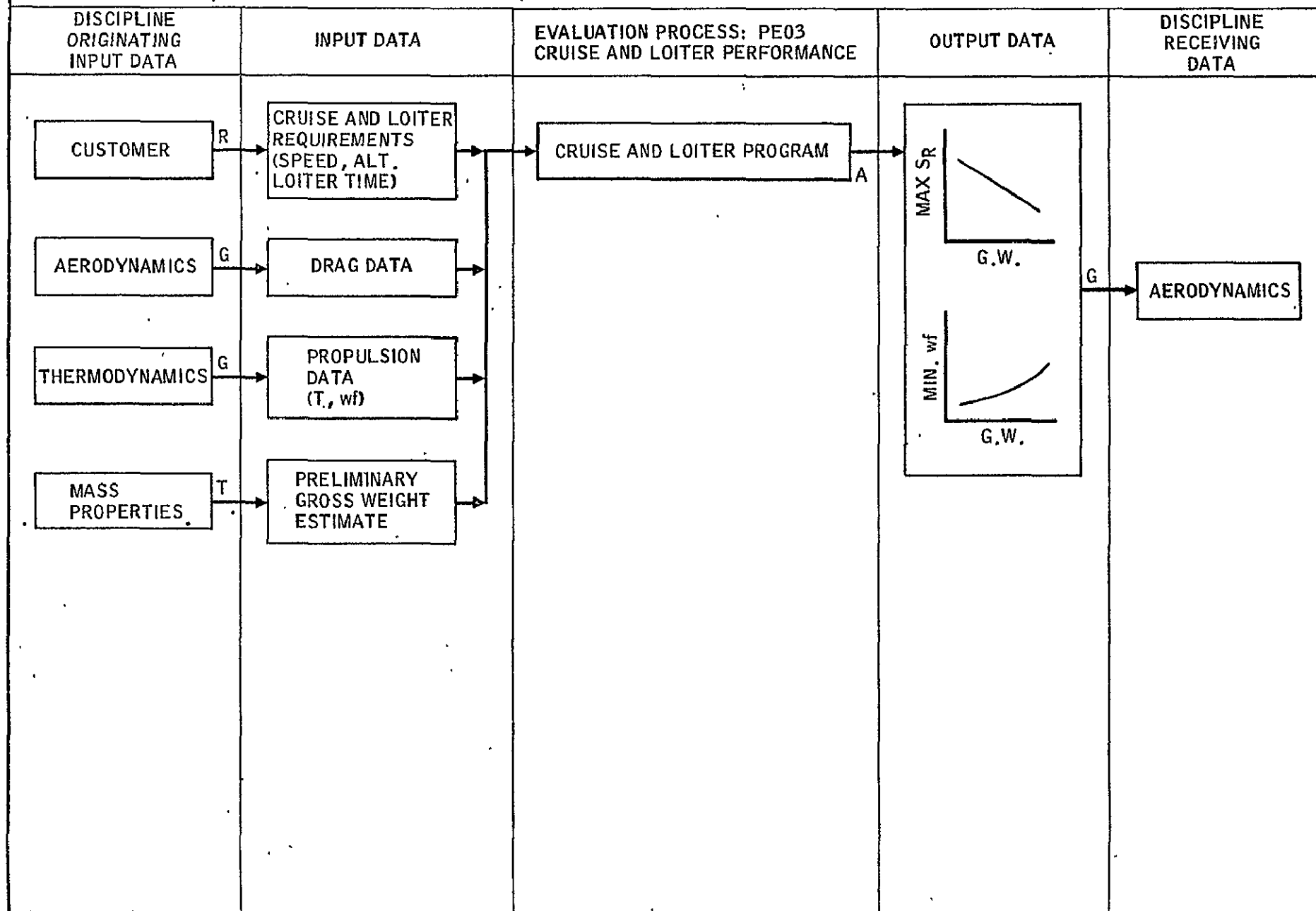


Figure 3-24. Climb Performance

DISCIPLINE: PERFORMANCE
CONCEPTUAL AND PRELIMINARY DESIGN PHASES



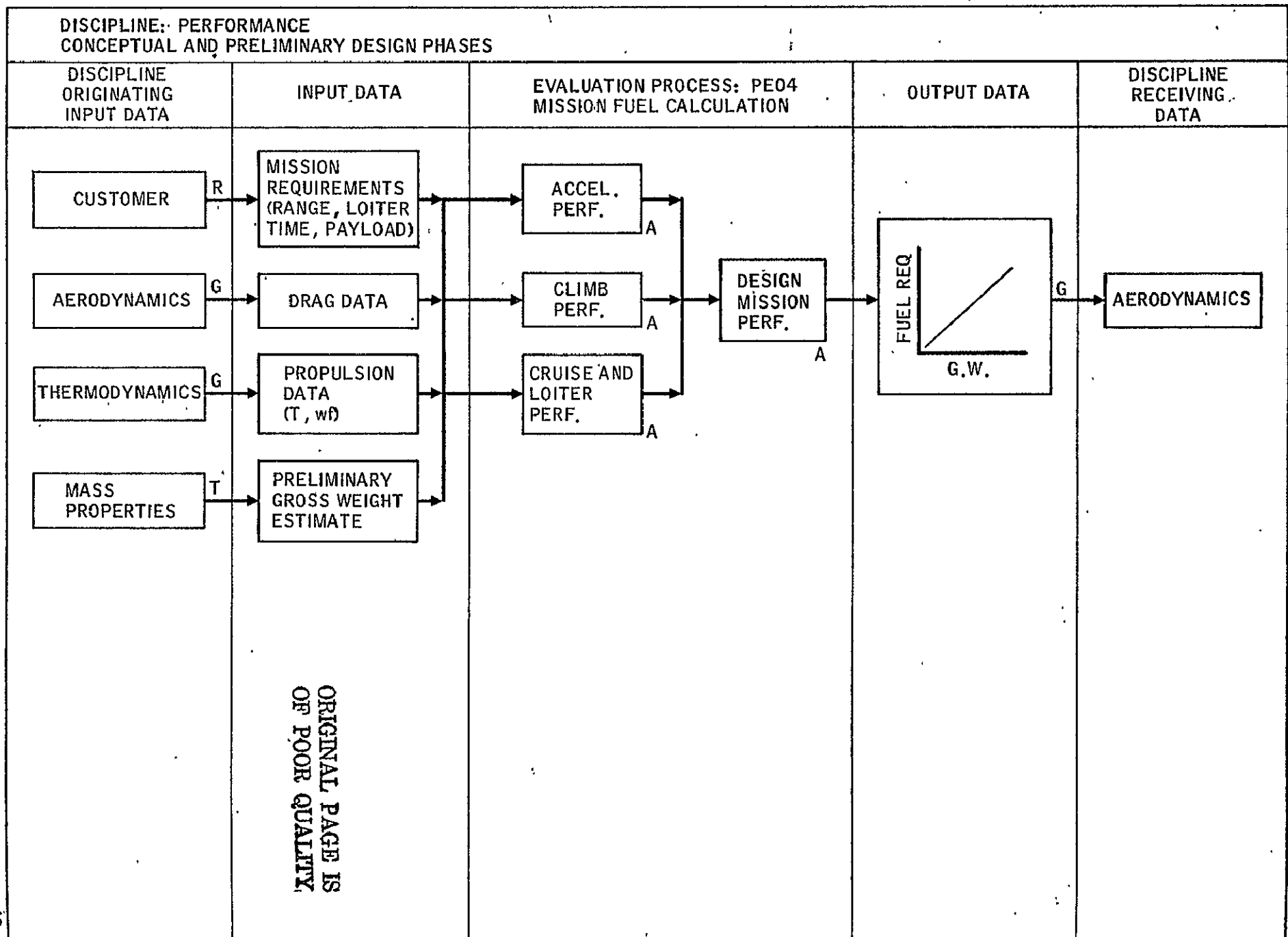
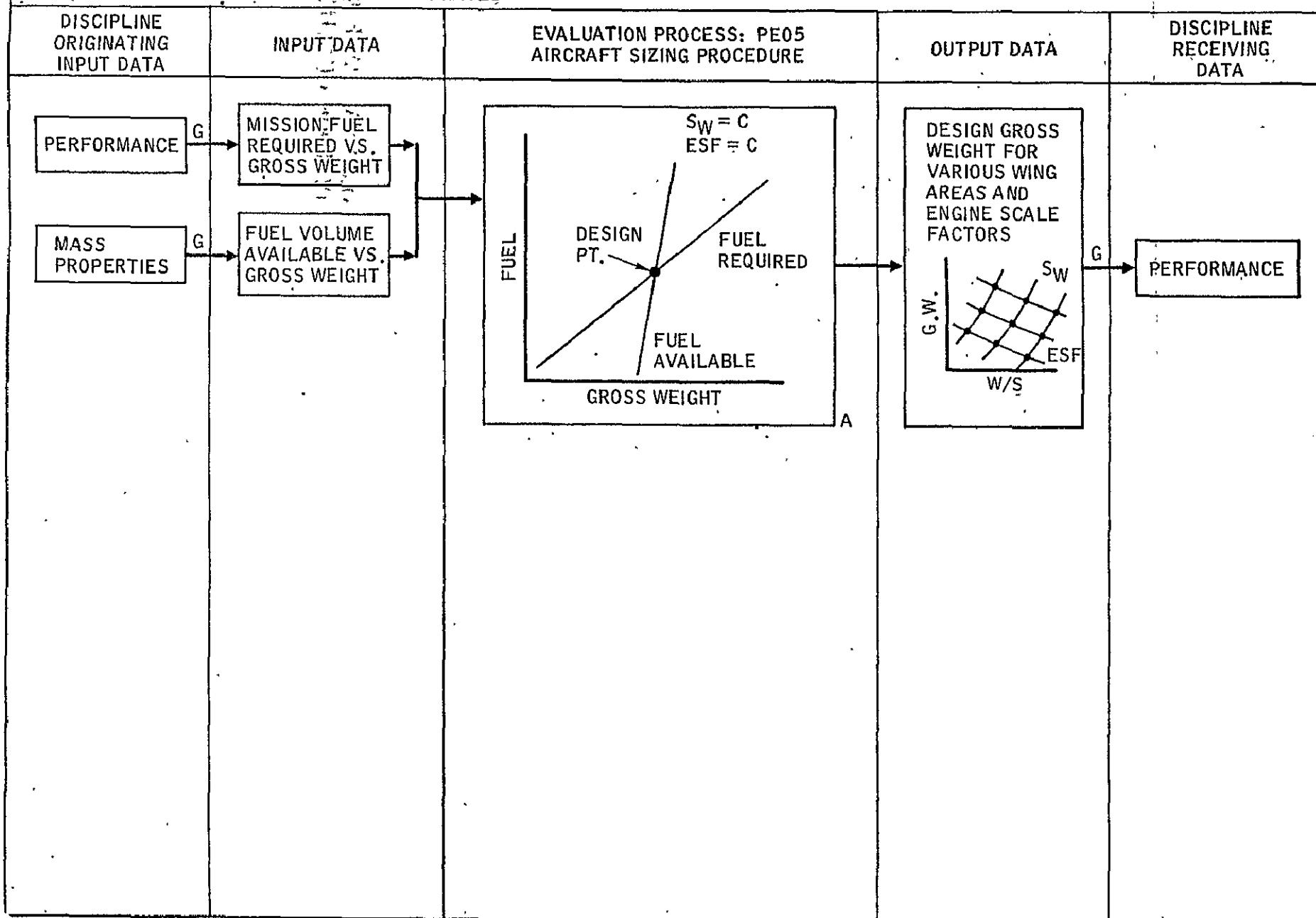


Figure 26. Mission Fuel Calculation

DISCIPLINE: PERFORMANCE
CONCEPTUAL AND PRELIMINARY DESIGN PHASES



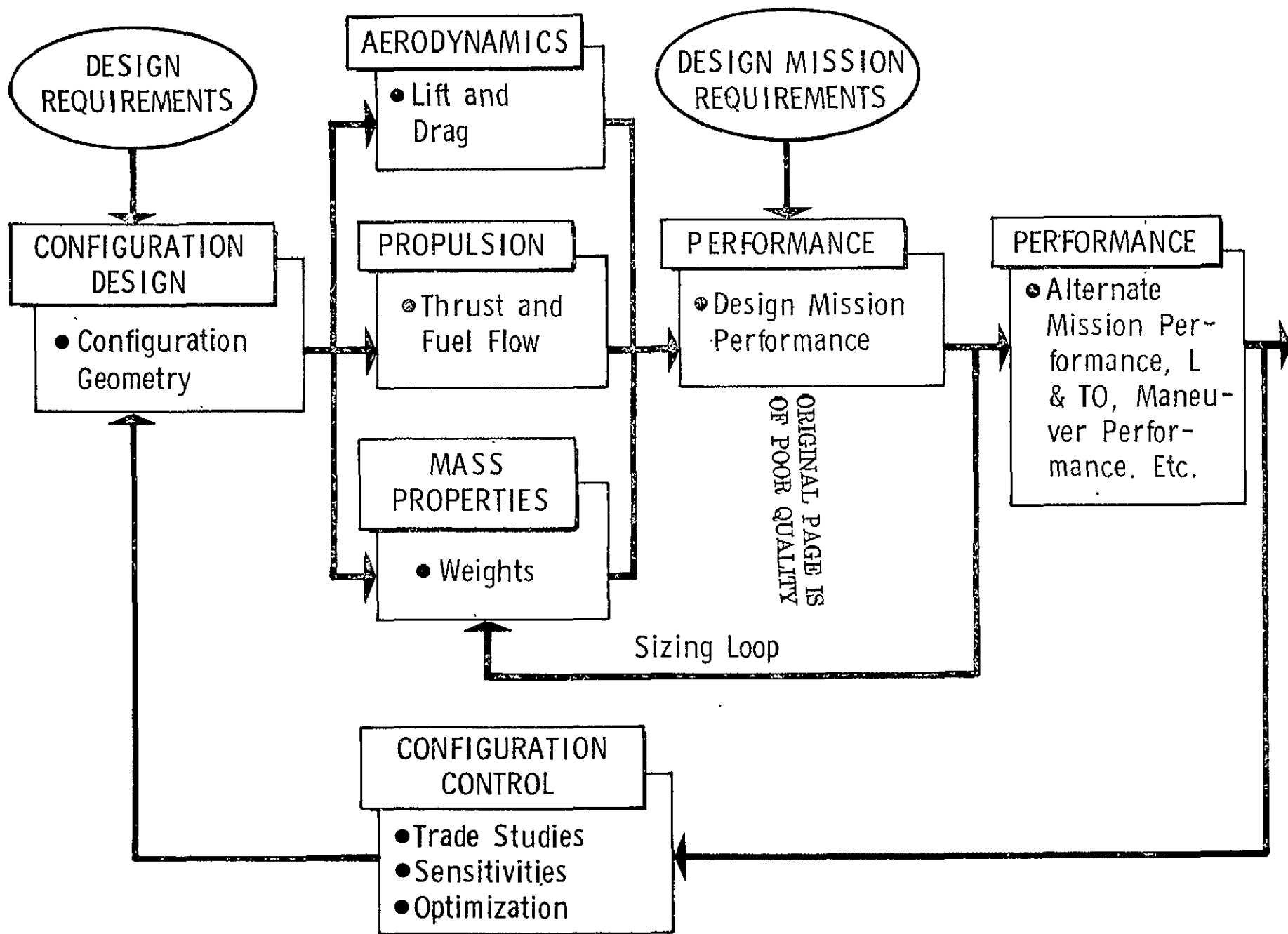
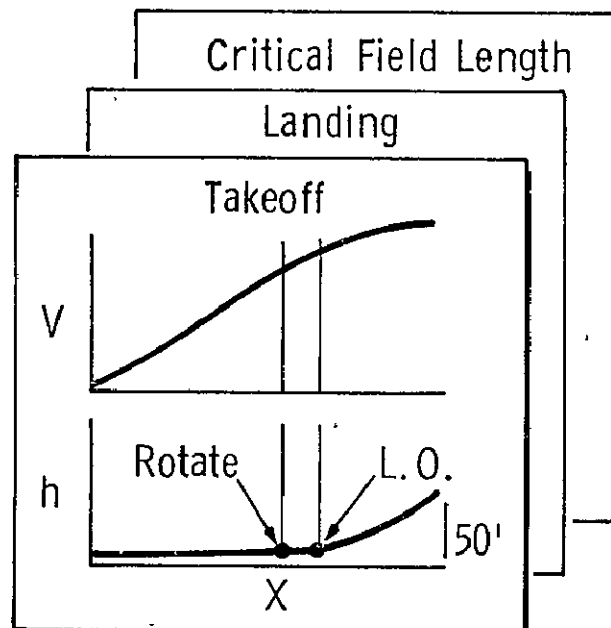
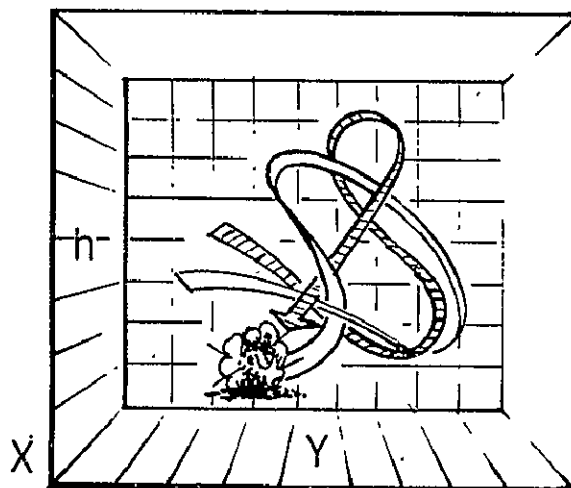


Figure 3-28. Sizing and Parametric Trade Studies

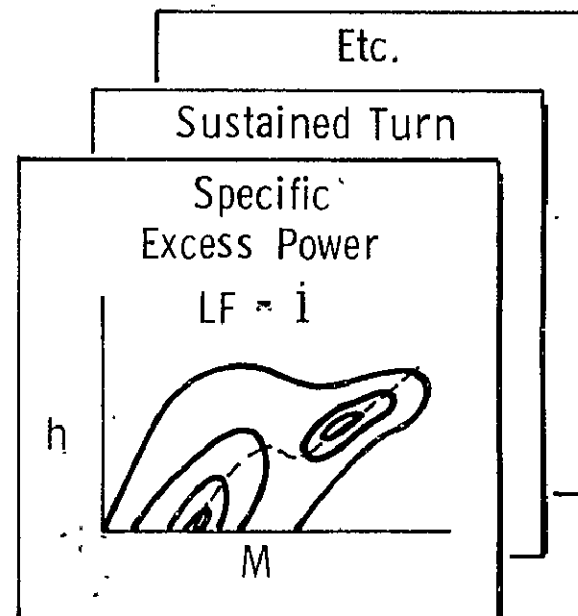
- TAKEOFF & LANDING



AIR COMBAT SIMULATION



- MANEUVERABILITY



- TERRAIN FOLLOWING
- BOMB RUNS
- OPTIMUM CLIMB, ACCELERATION, INTERCEPT, ETC.
- ... AND OTHERS

Figure 3-29. Flight Mechanics Analyses

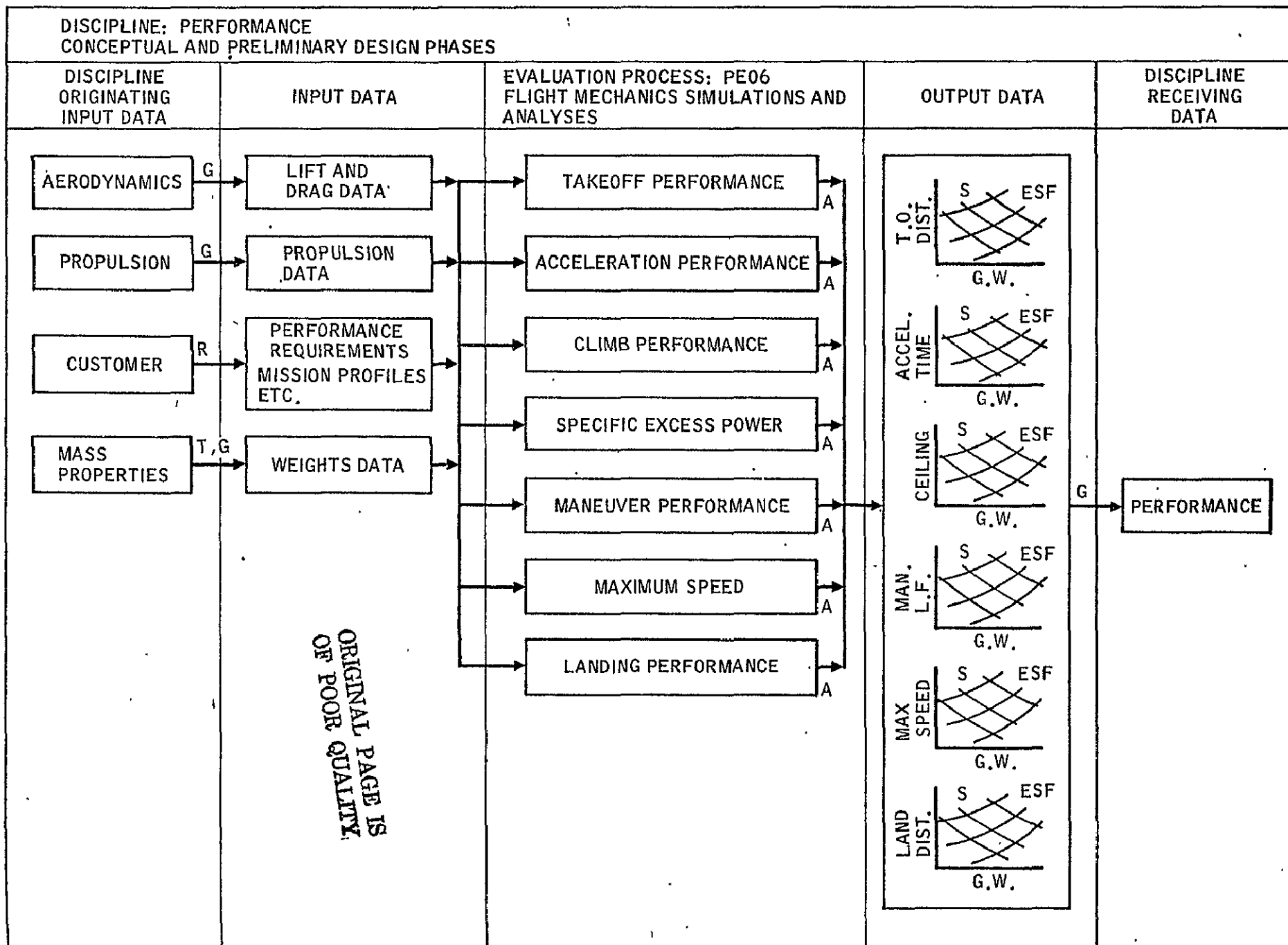
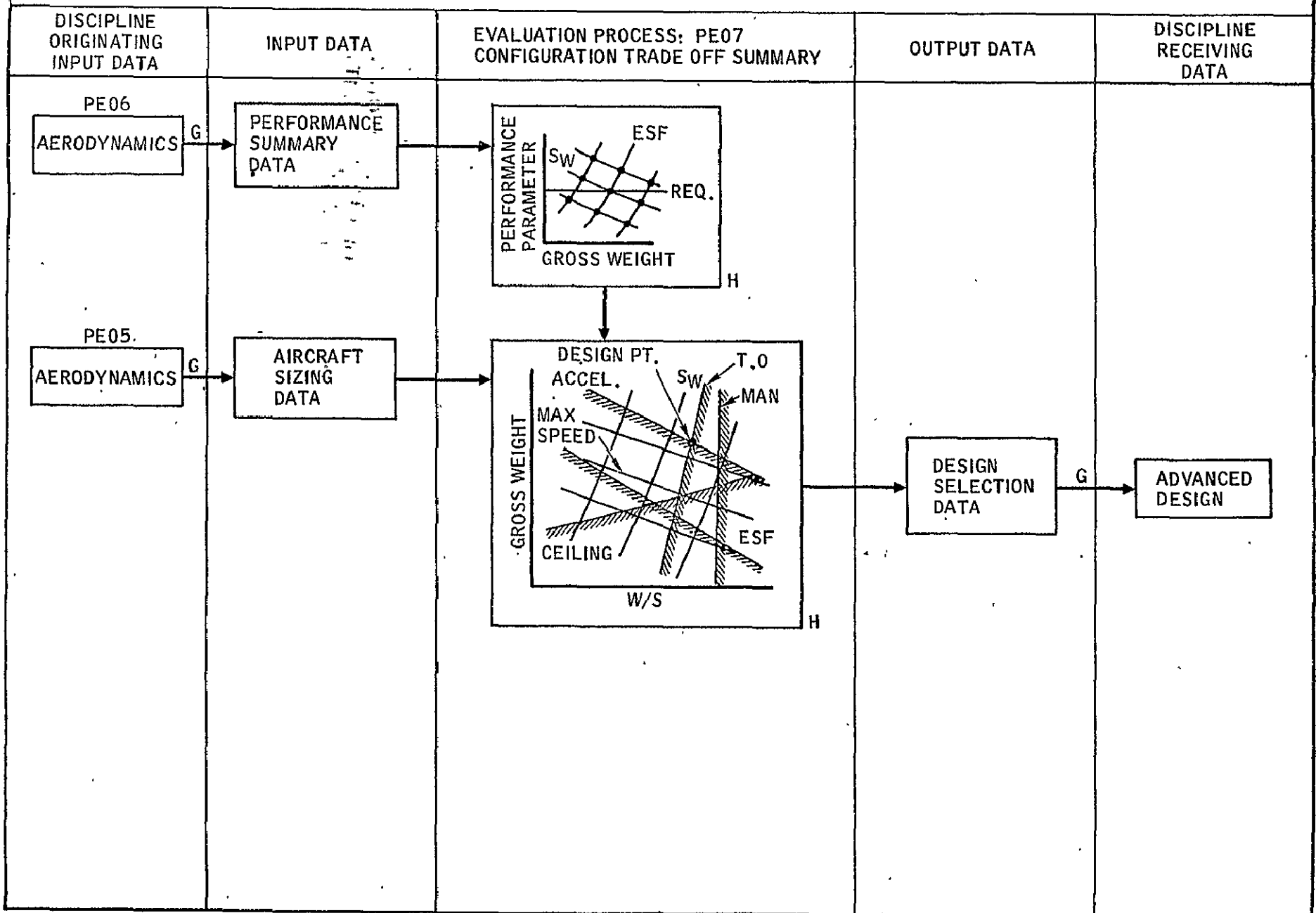


Figure 3-30. Flight Mechanics Simulations and Analyses

DISCIPLINE: PERFORMANCE
CONCEPTUAL AND PRELIMINARY DESIGN PHASES



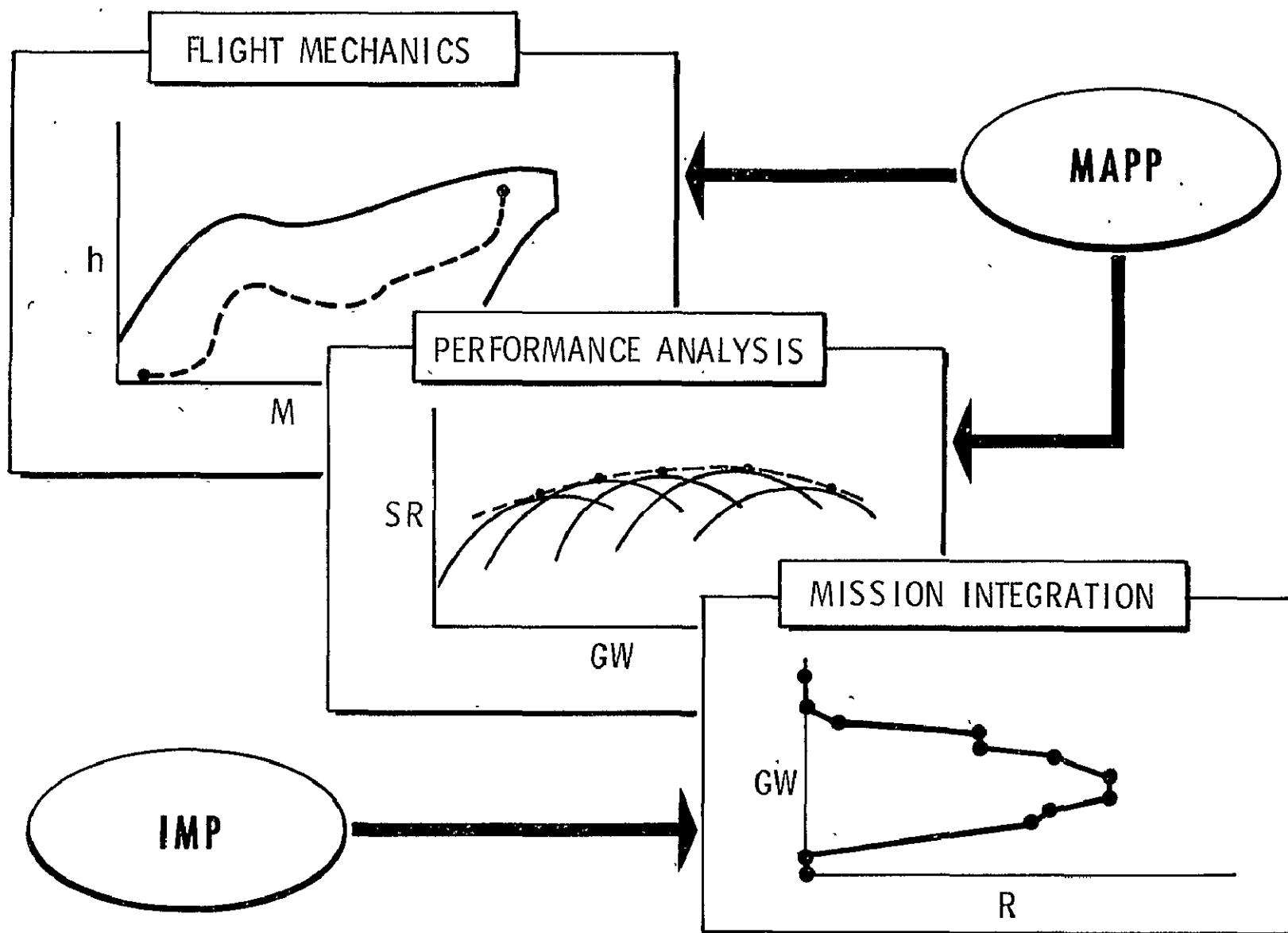


Figure 3-32. Mission Analysis and Performance System (MAPS)

TABLE 3-4. PROPULSION CEP'S AND COMPUTER PROGRAMS

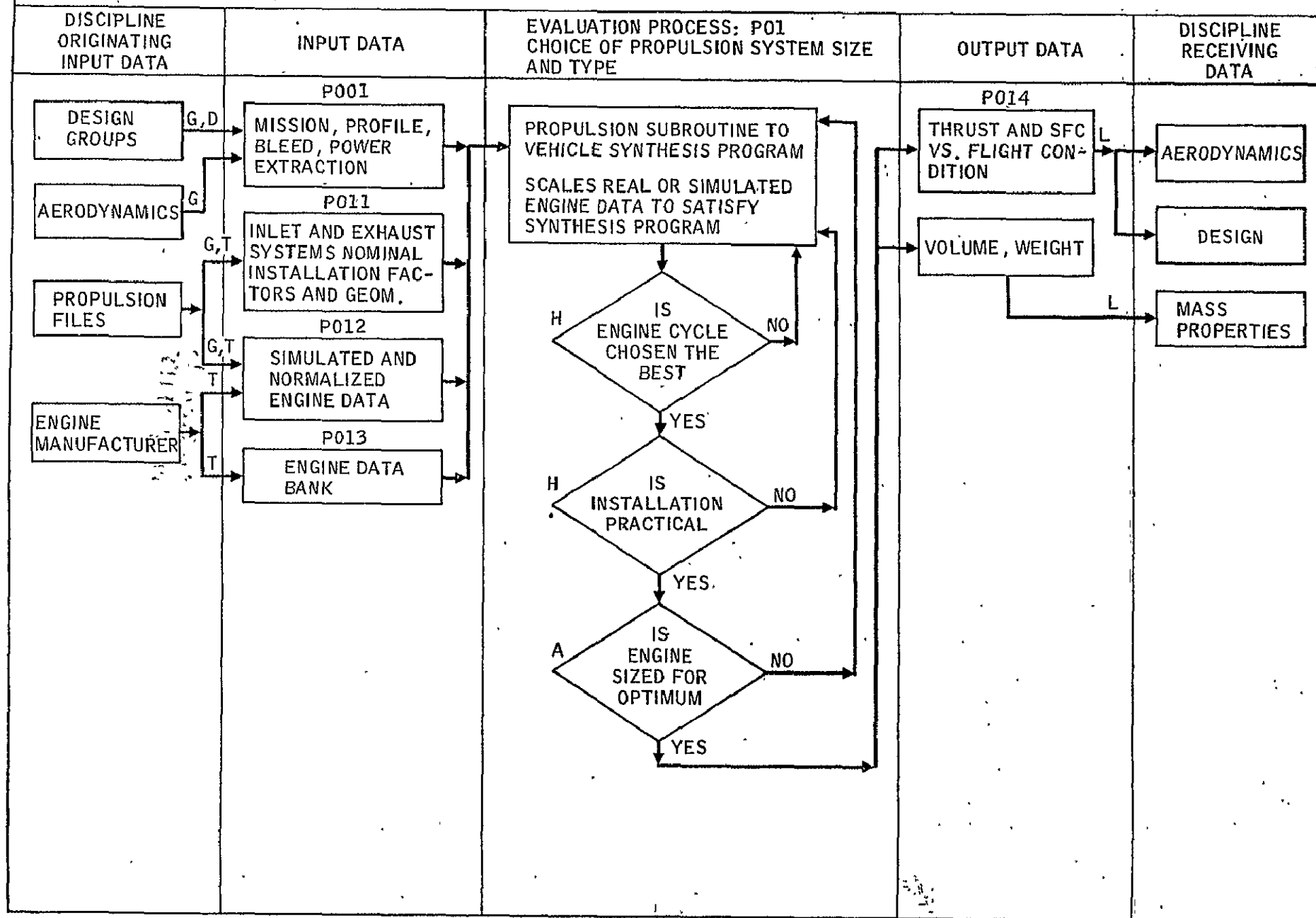
TASKS	CEP	Design Phase		
		C	PD	DD
Choice of Propulsion System Size & Type	P01	x		
Propulsion System Analysis (Inlet, Exhaust, Bleed, Power, Noise, IR)	P02	x	x	x
Inlet Type and Location Selection	P05	x	x	x
Specification of Forebody Design Constraints	P06		x	x
Prediction of Flow-Field at Inlet Location	P06		x	x
Inlet Size, Orientation, Aspect Ratio Selection	P05	x	x	x
Inlet Compression Surface, Variable Geometry & Subsonic Duct Design	P05		x	x
Inlet Lip, Sideplate, etc., Design	P05			x
Inlet Boundary Layer Bleed and Bypass System Design	P05		x	x
Inlet Blow-in Door (or Auxiliary Inlet) Design	P05		x	x
Predict Inlet Drag and Pressure Recovery	P04	x	x	x
Predict Boundary Layer Bleed and Bypass Rates	P04		x	x
Inlet Control System Concept Design	P03		x	x
Predict Pressures for Inlet Loads	P04		x	x
Secondary Air System Internal Performance	P08	x	x	x
Secondary Air System Design	P08		x	x
Prediction of Distortion and/or Turbulence	P05			x
Nozzle Installed Internal Performance	P10	x	x	x
Nozzle Installed External Drag	P10	x	x	x
Nozzle External Air Loads	P09			x
Nozzle Selection	P09	x	x	x
Engine Cycle Selection	P12	x	x	
Installed Engine Performance Prediction	P11	x	x	x
Engine Control System Characteristics Selection	P12	x	x	x
Predict Scaled Engine Physical Characteristics	P12	x	x	
Engine Transient Performance	P11		x	x
Predict Engine IR and Radar Signatures	P11		x	x
Noise Predictions	P11	x	x	x
Estimate Bleed System Requirements	P11		x	x
Estimate Power Extraction Requirements	P11		x	x
Predict Air Conditioning System Performance	T04	x	x	x
Size Air Conditioning System	T04	x	x	x
Establish Distribution System Requirements	T04		x	x

TABLE 3-4. PROPULSION CEP'S AND COMPUTER PROGRAMS (CONT'D)

TASKS		CEP	Design Phase		
			C	PD	DD
Predict Performance of Anti-icing Systems		T02	x	x	x
Size Anti-icing/De-icing Systems		T02		x	x
Size Rain Clearing System and Show Performance		T02			x
Size and Predict Performance of Engine Cooling System		T03		x	x
Size and Predict Performance of Engine and Hydraulic Cooling		T03		x	x
Size and Predict Performance of Generator and Drive Cooling		T03		x	x
Size and Predict Performance of Structural Cooling		T03	x	x	x
Size De-fog System and Show Performance		T02			x
<u>COMPUTER PROGRAMS</u>					
Propul	Subroutine in Aero Synthesis Program	P01	x		
Epic	Subroutine or Main to Generate Internal Performance Losses	P02	x	x	
Inst	Main or Subroutine to Correct for External Inst. Losses	P02	x	x	
AIV	Characteristic Solution of Rotationally Symmetric Flow Fields	P07		x	x
A5M	Focused Isentropic Spike Design	P07		x	x
A5T	Conical Flow Field	P07		x	x
A6C	Oblique Shocks at High Mach Number	P07		x	x
SF7-A	Supersonic Flow Field & Boundary Layer Analysis	P07		x	x
C76	Supersonic Internal Flow Analysis	P07		x	x
SL6	Two-Dimensional Triple-Ramp Inlet Flow Field Properties	P07		x	x
SYO	Airbreathing Engine Cycle Analysis	P13	x		
	Air Conditioning System Analysis	T04	x	x	x
	Heat Exchanger Analysis	T03		x	x
	External Supersonic Inlet Performance	P02	x	x	

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DISCIPLINE: PROPULSION THERMODYNAMICS CONCEPTUAL DESIGN PHASE



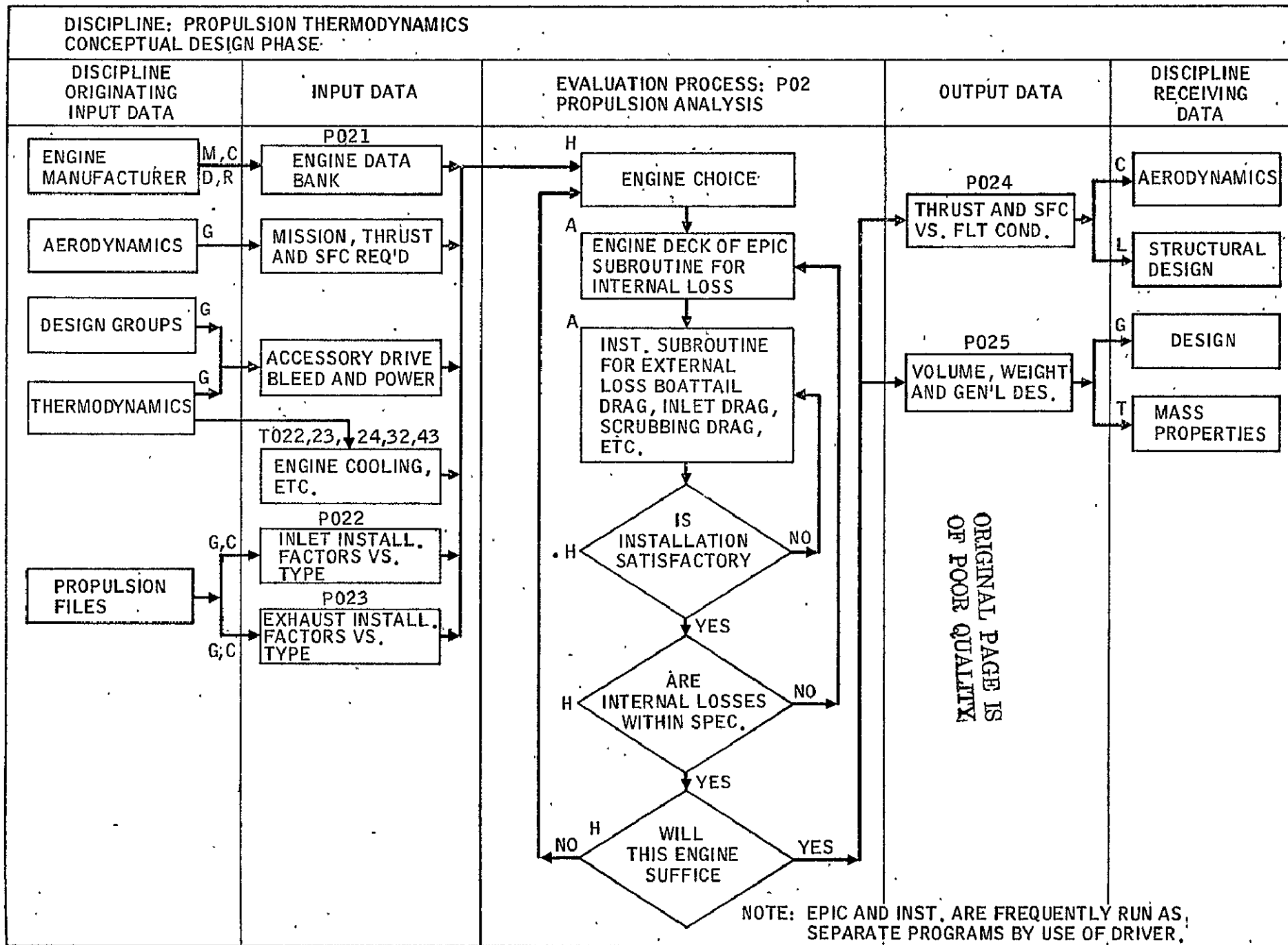


Figure 3-34. Propulsion Analysis

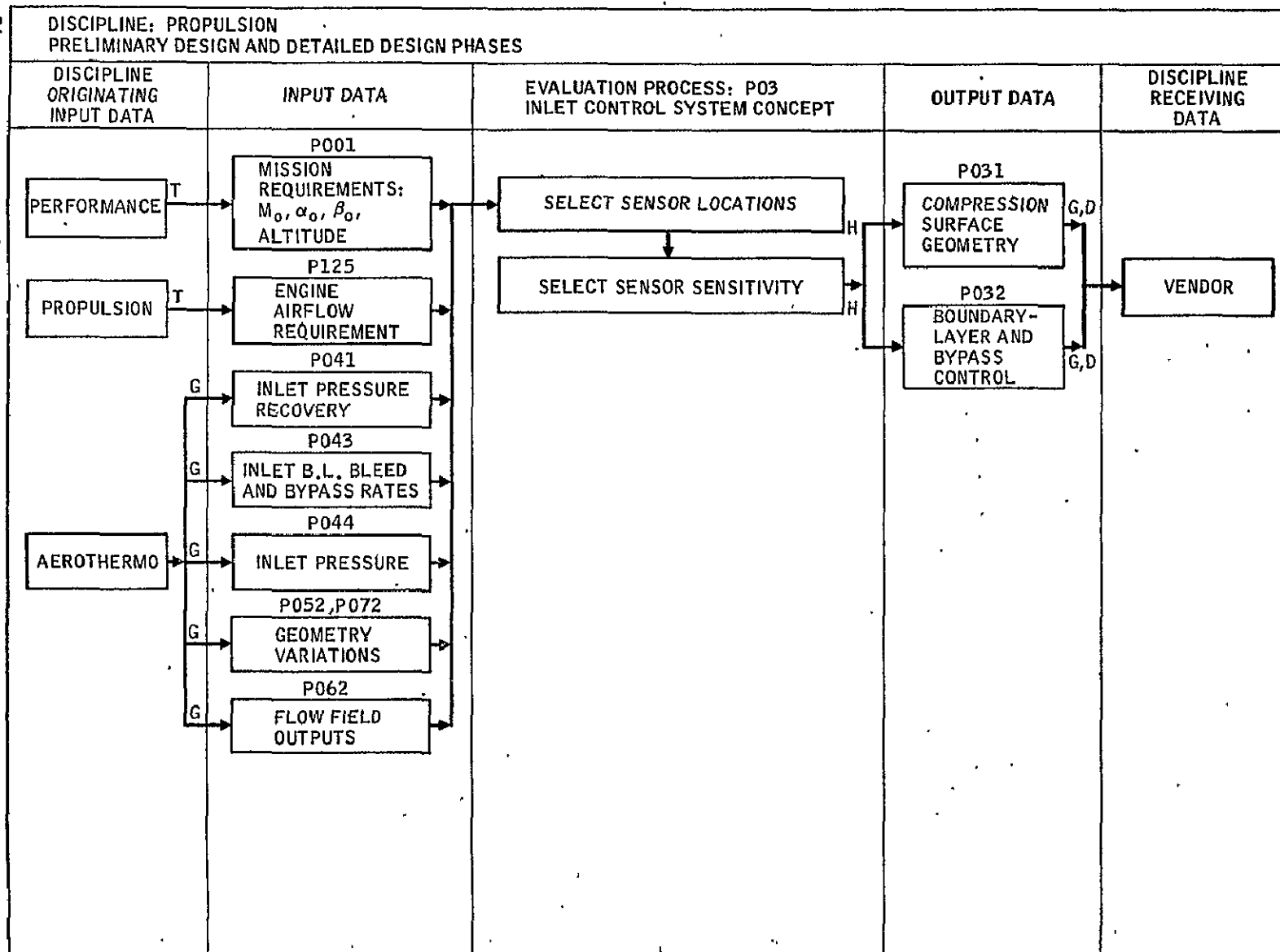


Figure 3-35. Inlet Control System Concept

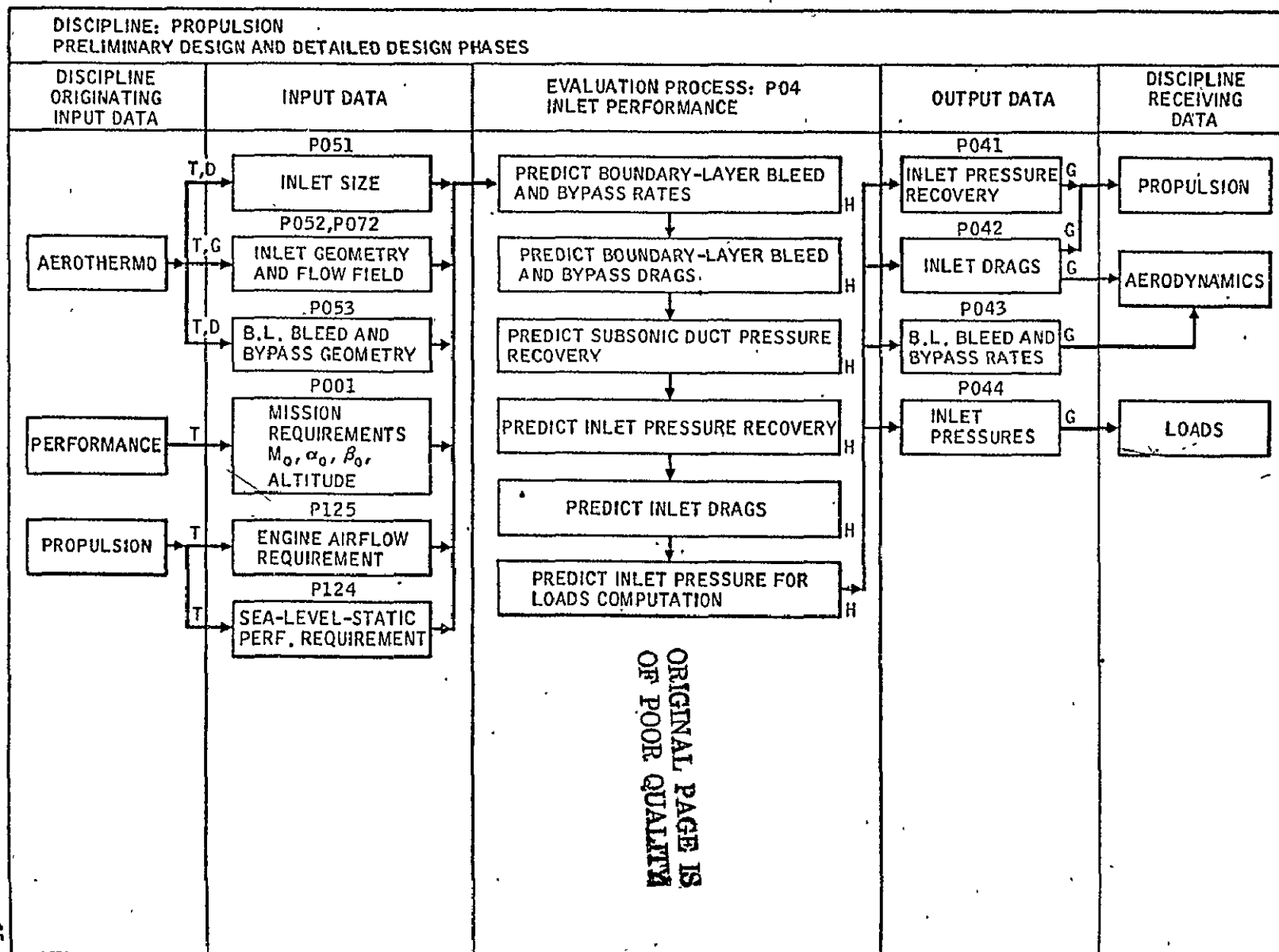
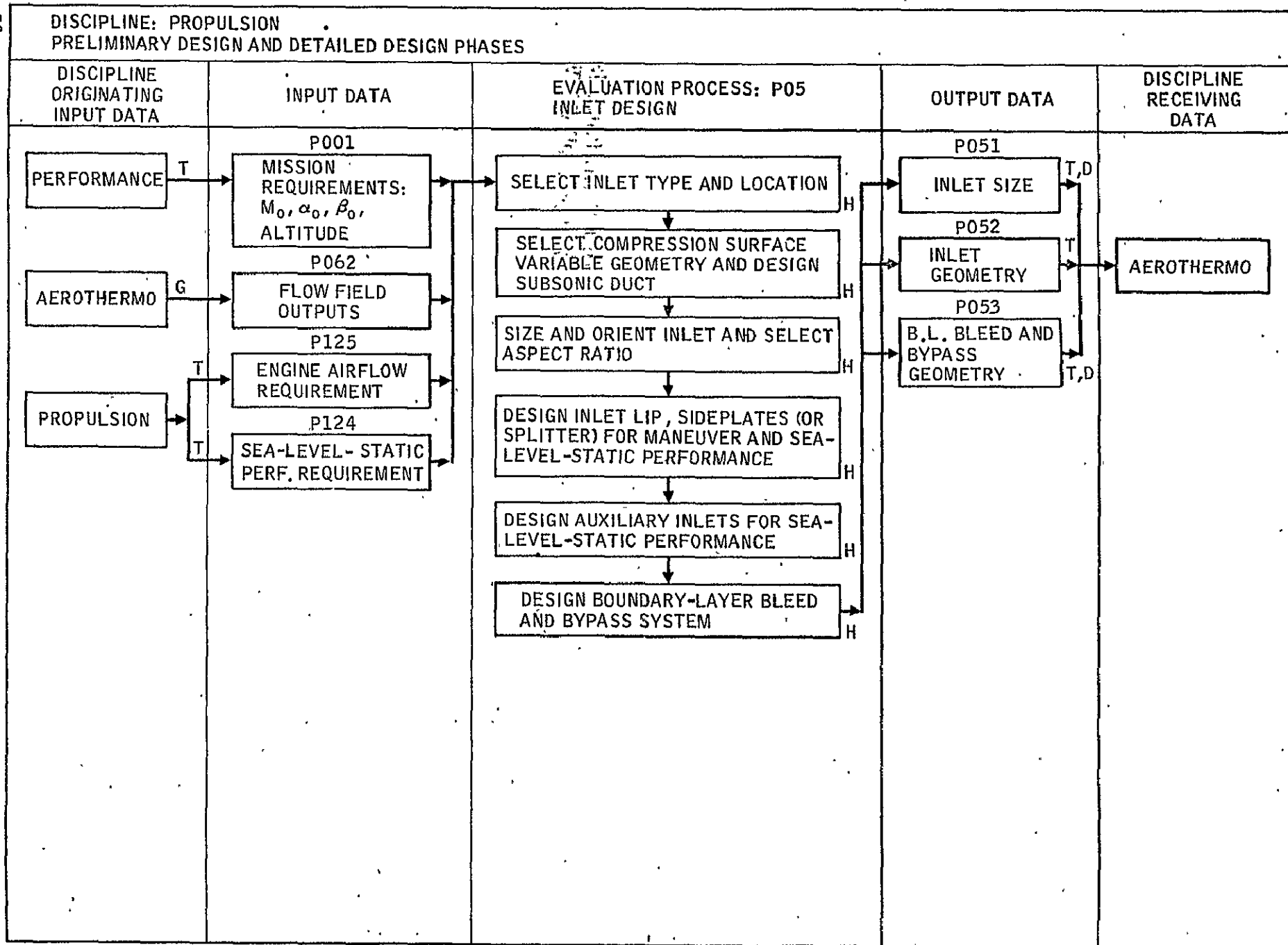


Figure 3-30. Inlet Performance



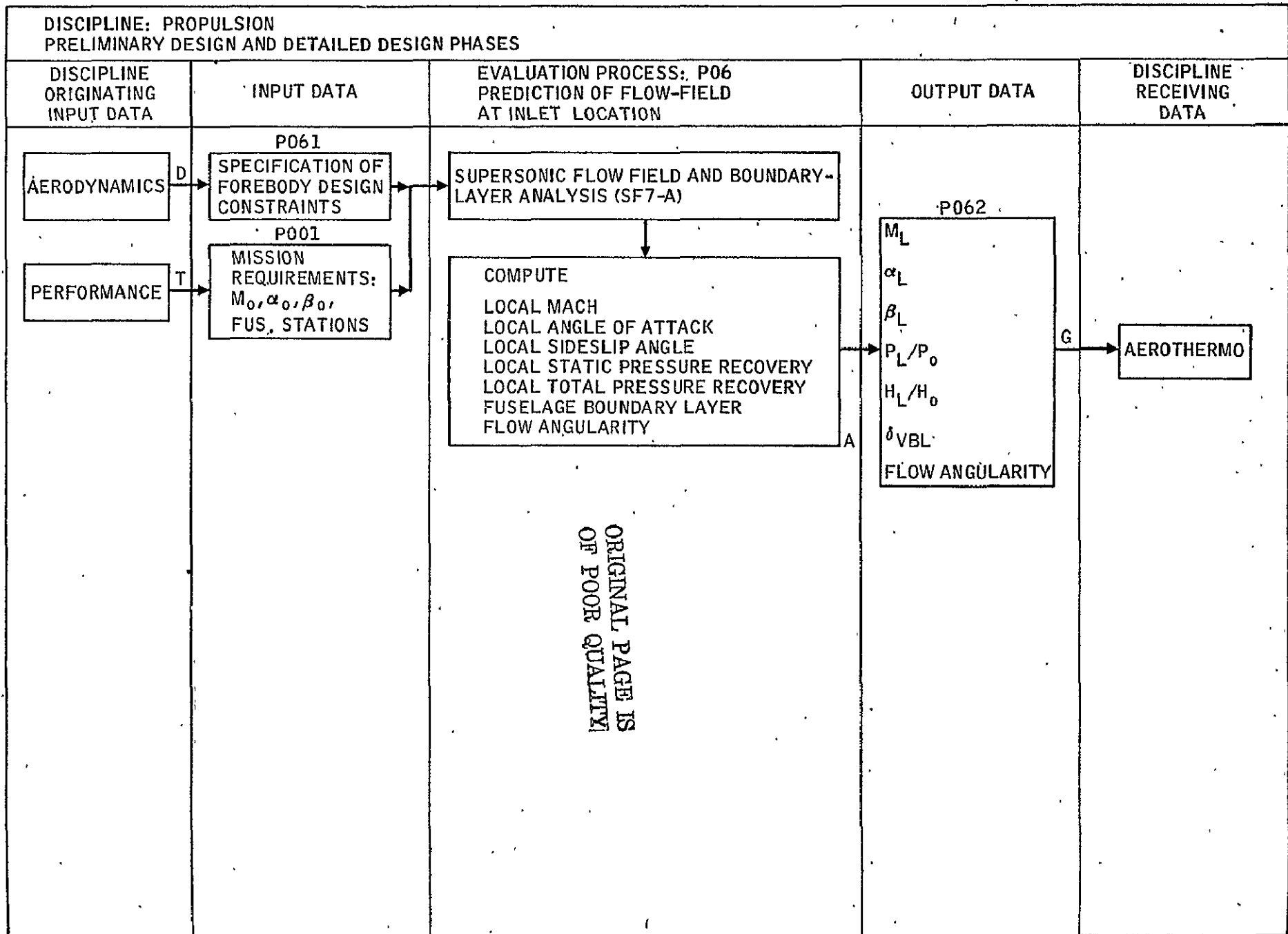
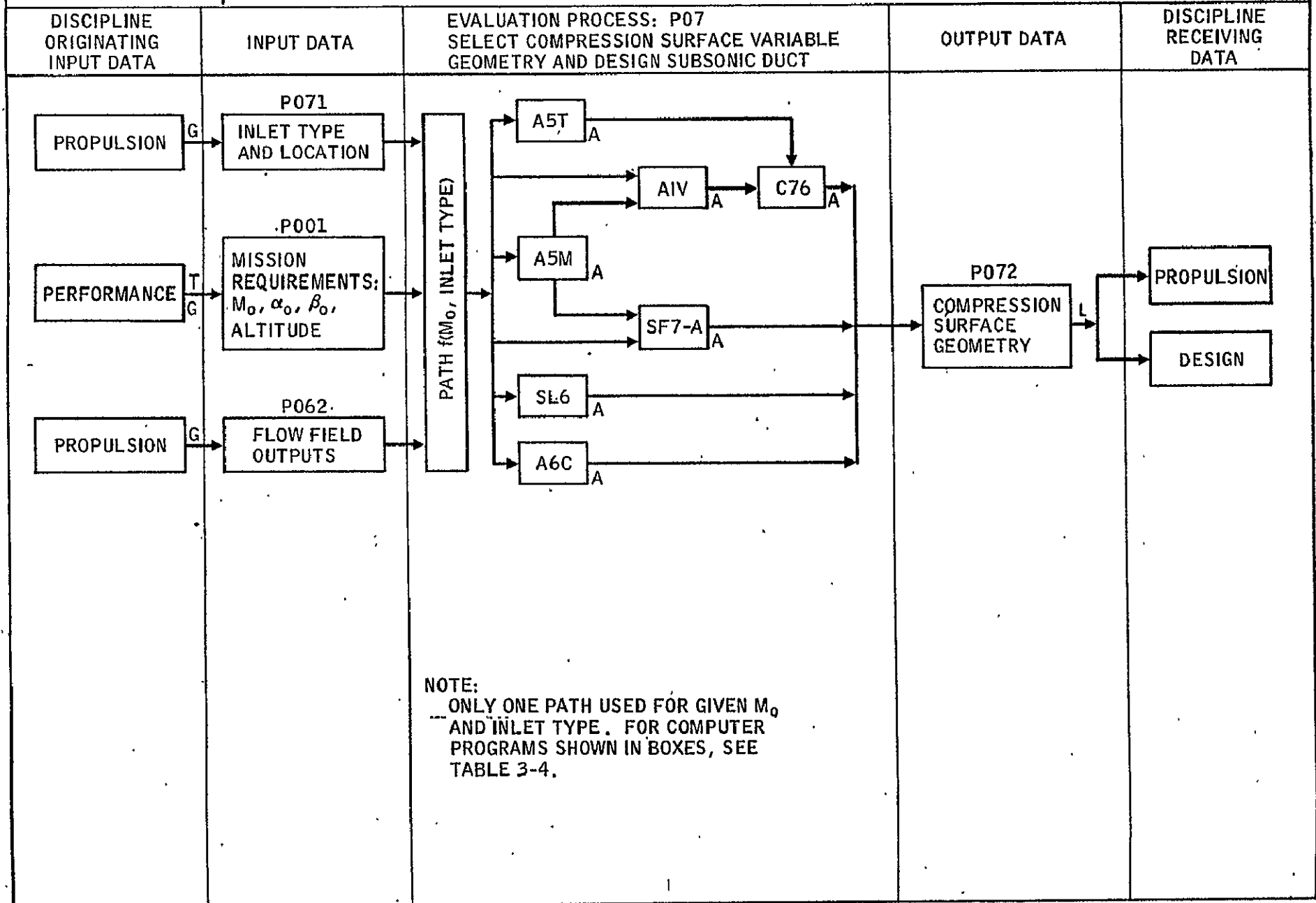


Figure 3-38. Prediction of Flow Field at Inlet Location

DISCIPLINE: PROPULSION
PRELIMINARY DESIGN AND DETAILED DESIGN PHASES



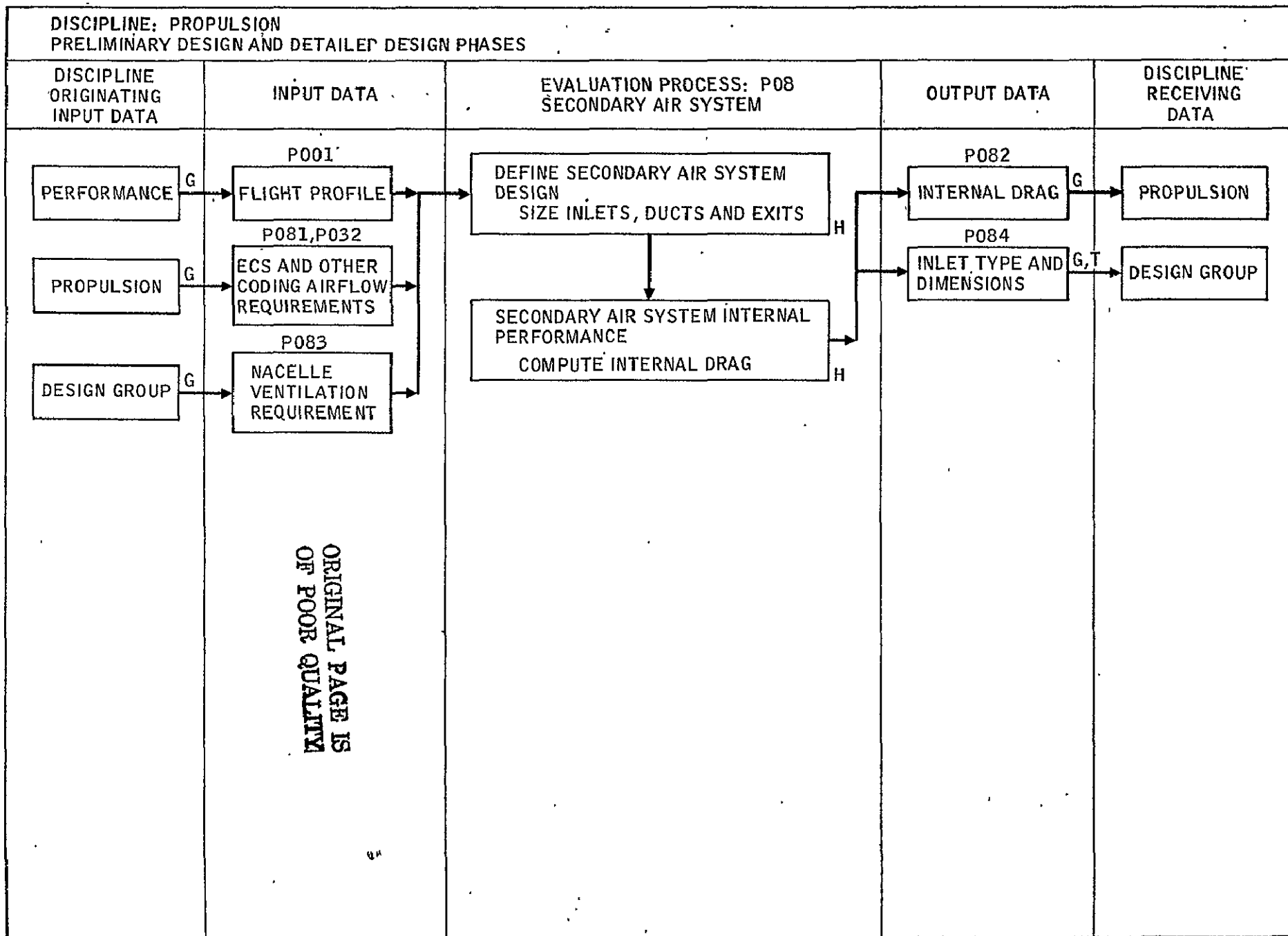
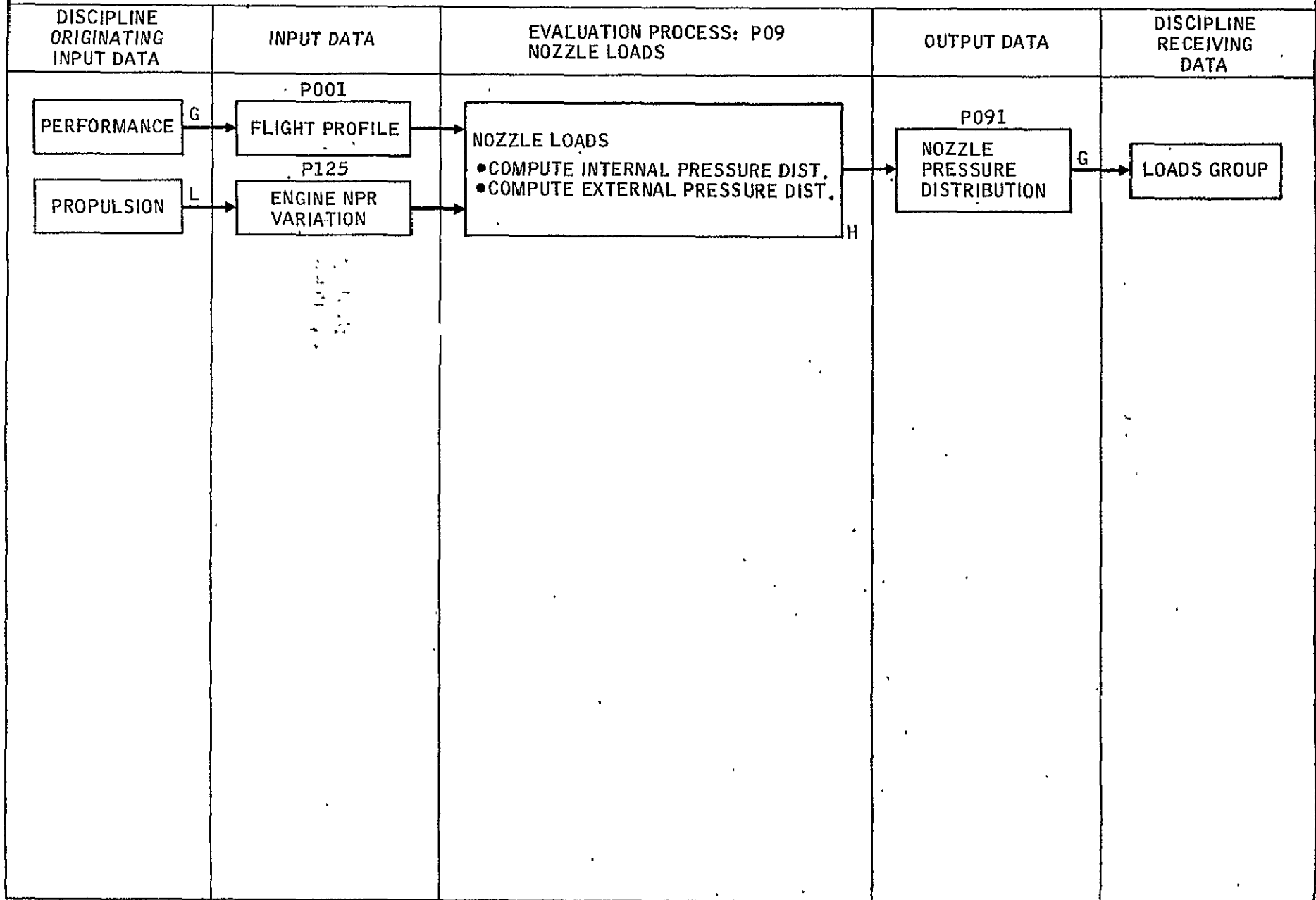


Figure 3-40. Secondary Air System

DISCIPLINE: PROPULSION
PRELIMINARY DESIGN AND DETAILED DESIGN PHASES



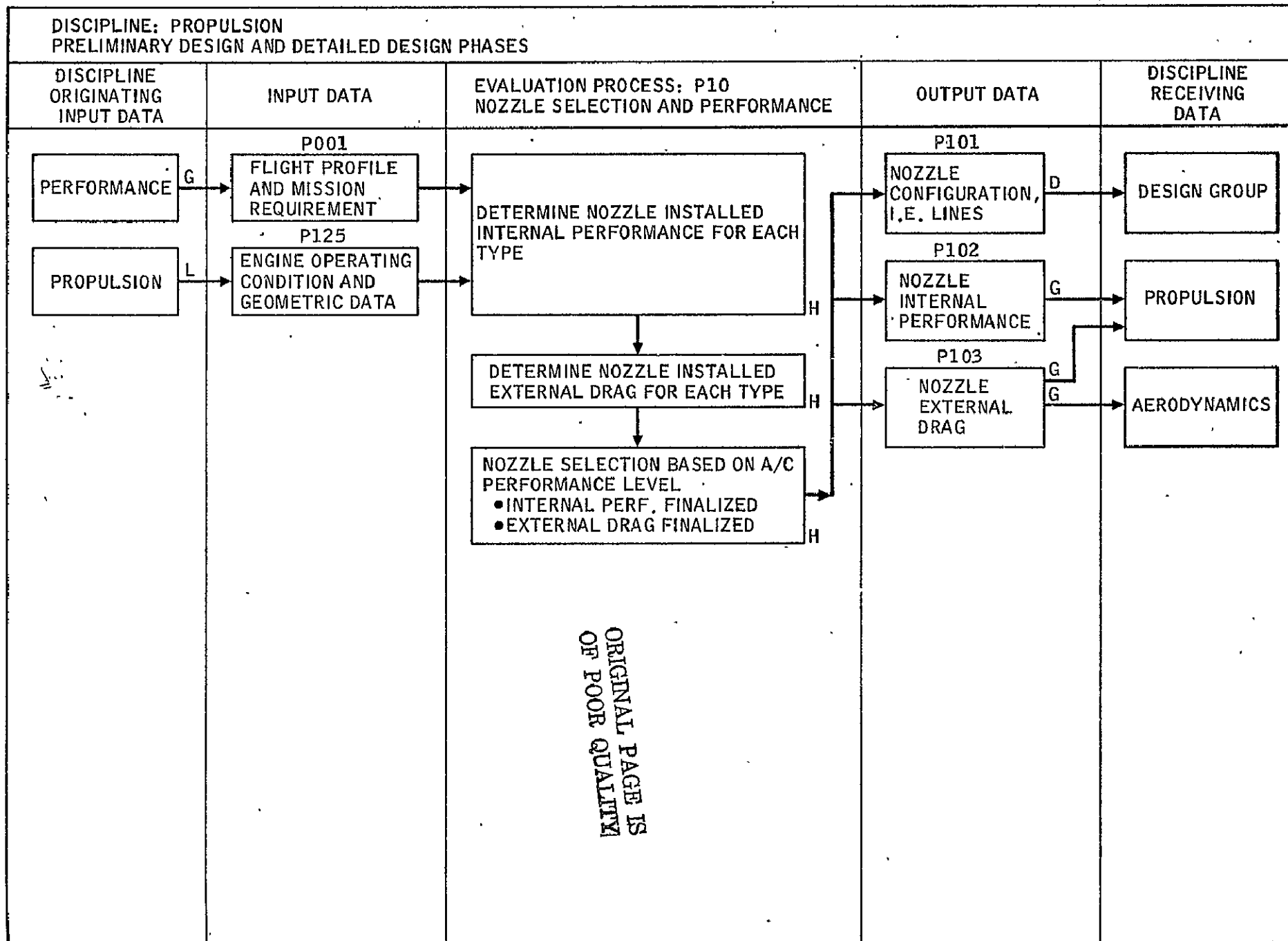


Figure 3-42. Nozzle Selection and Performance

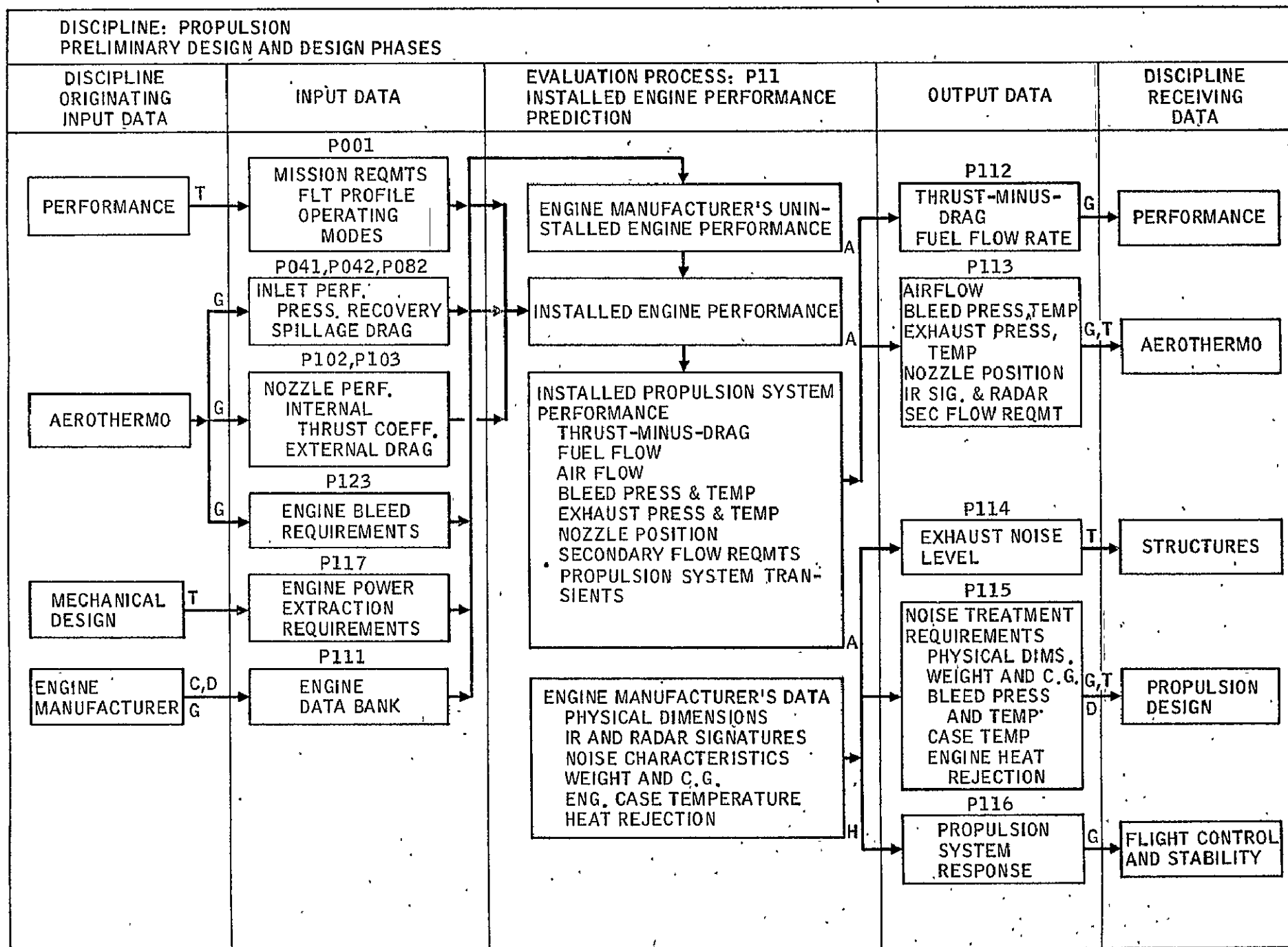


Figure 3-43. Installed Engine Performance Prediction

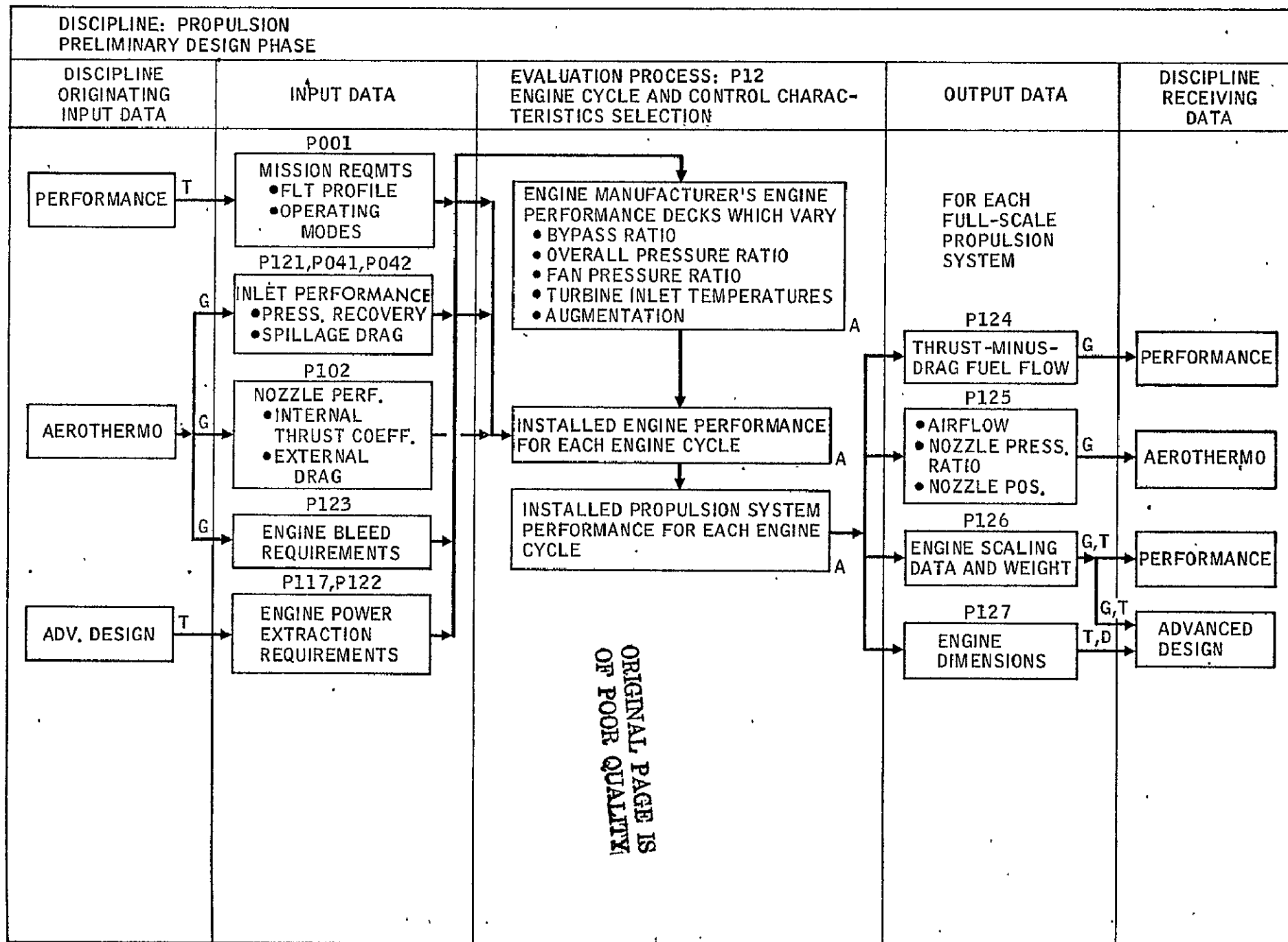
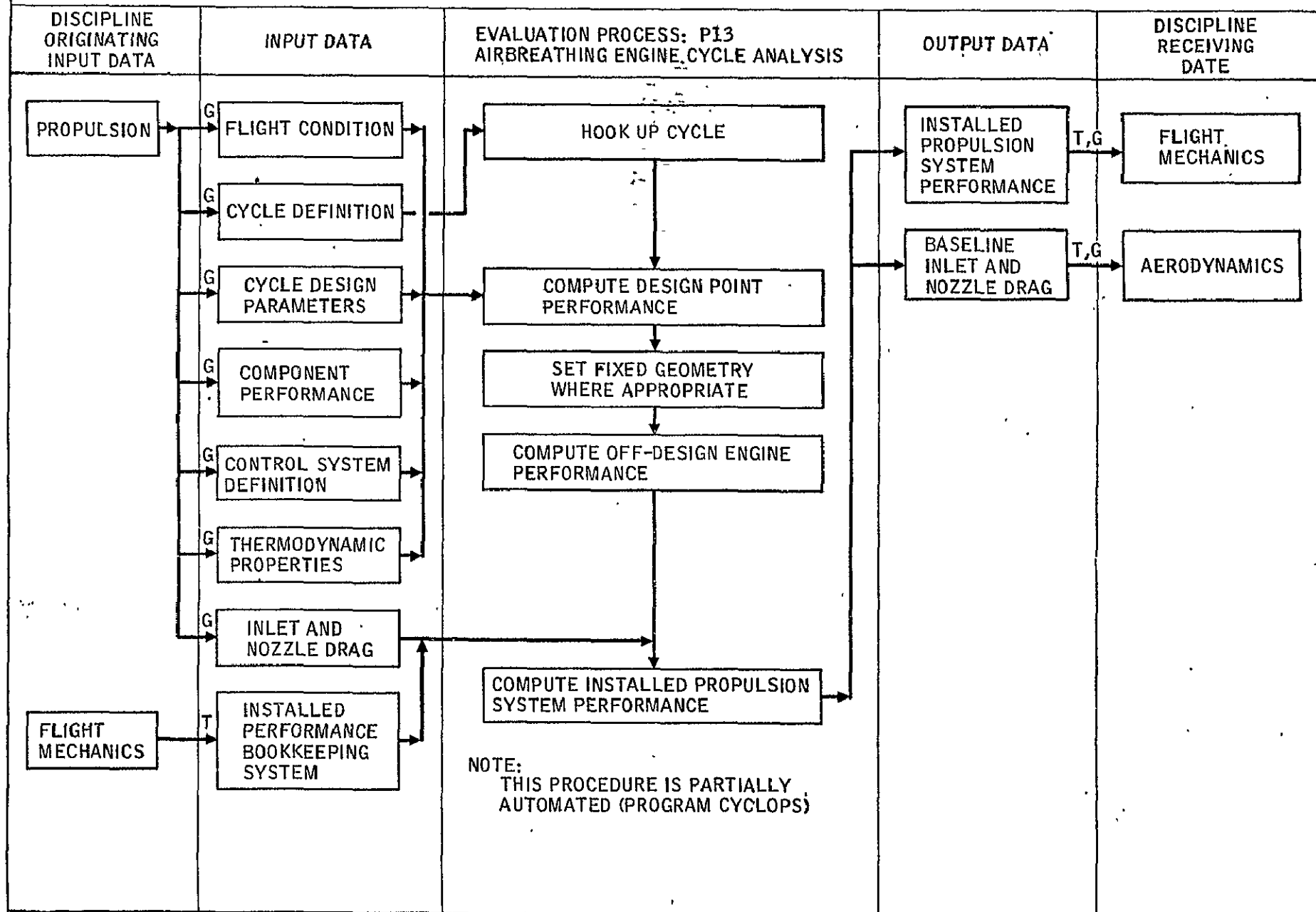


Figure 3-44. Engine Cycle and Control Characteristic Selection

DISCIPLINE: PROPULSION CONCEPTUAL DESIGN PHASE



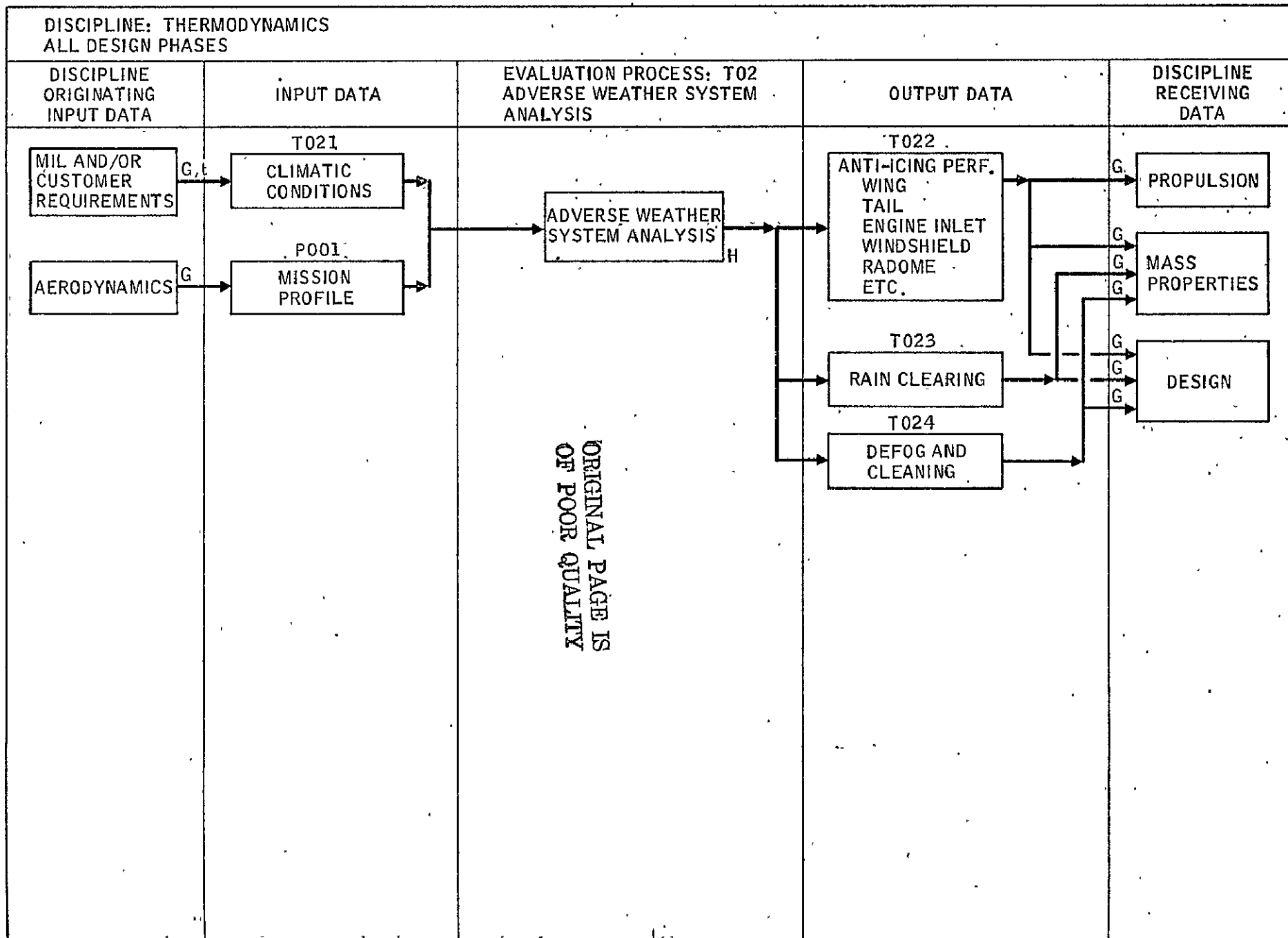
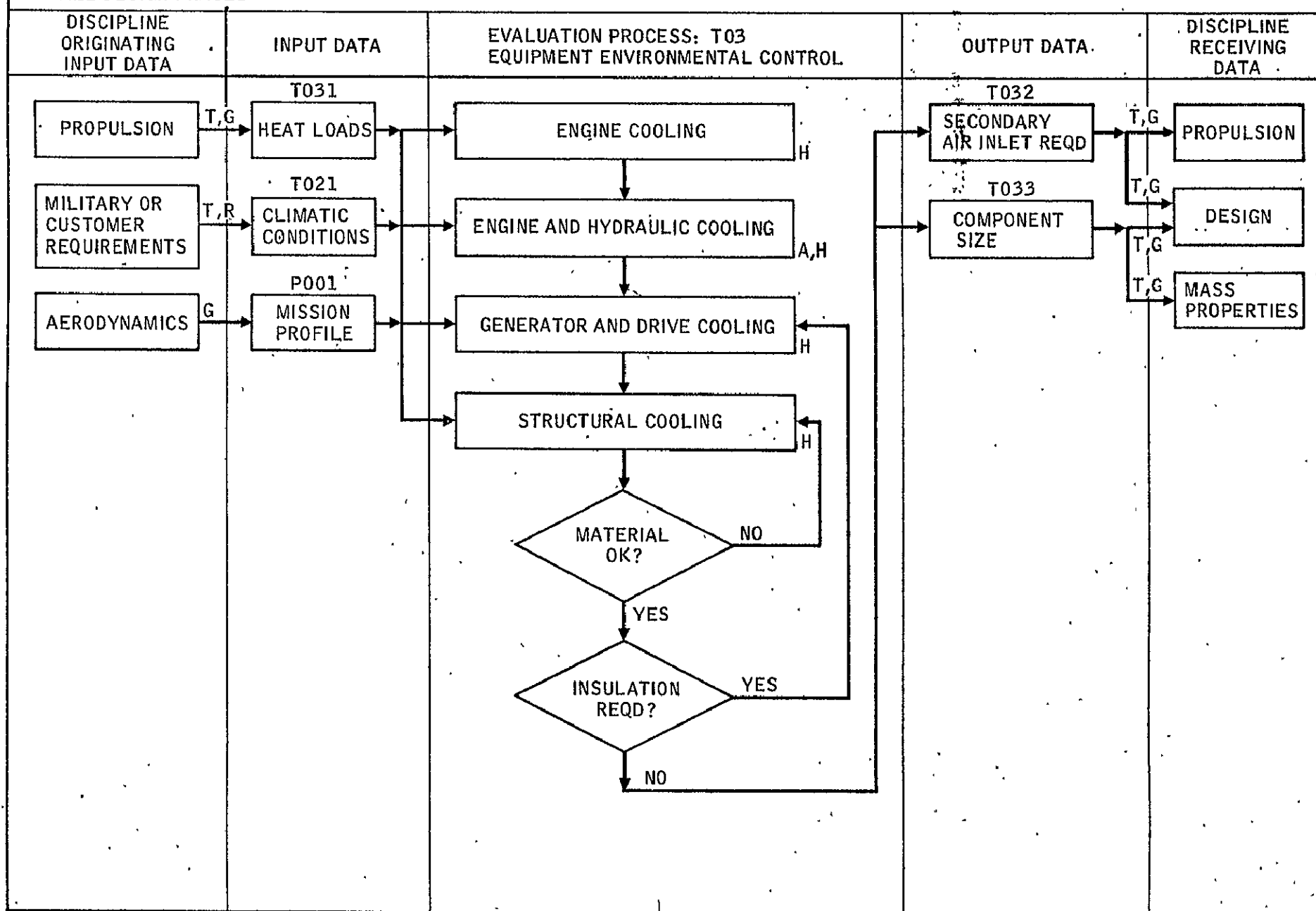


Figure 3-46. Adverse Weather System Analysis

DISCIPLINE: THERMODYNAMICS
ALL DESIGN PHASES



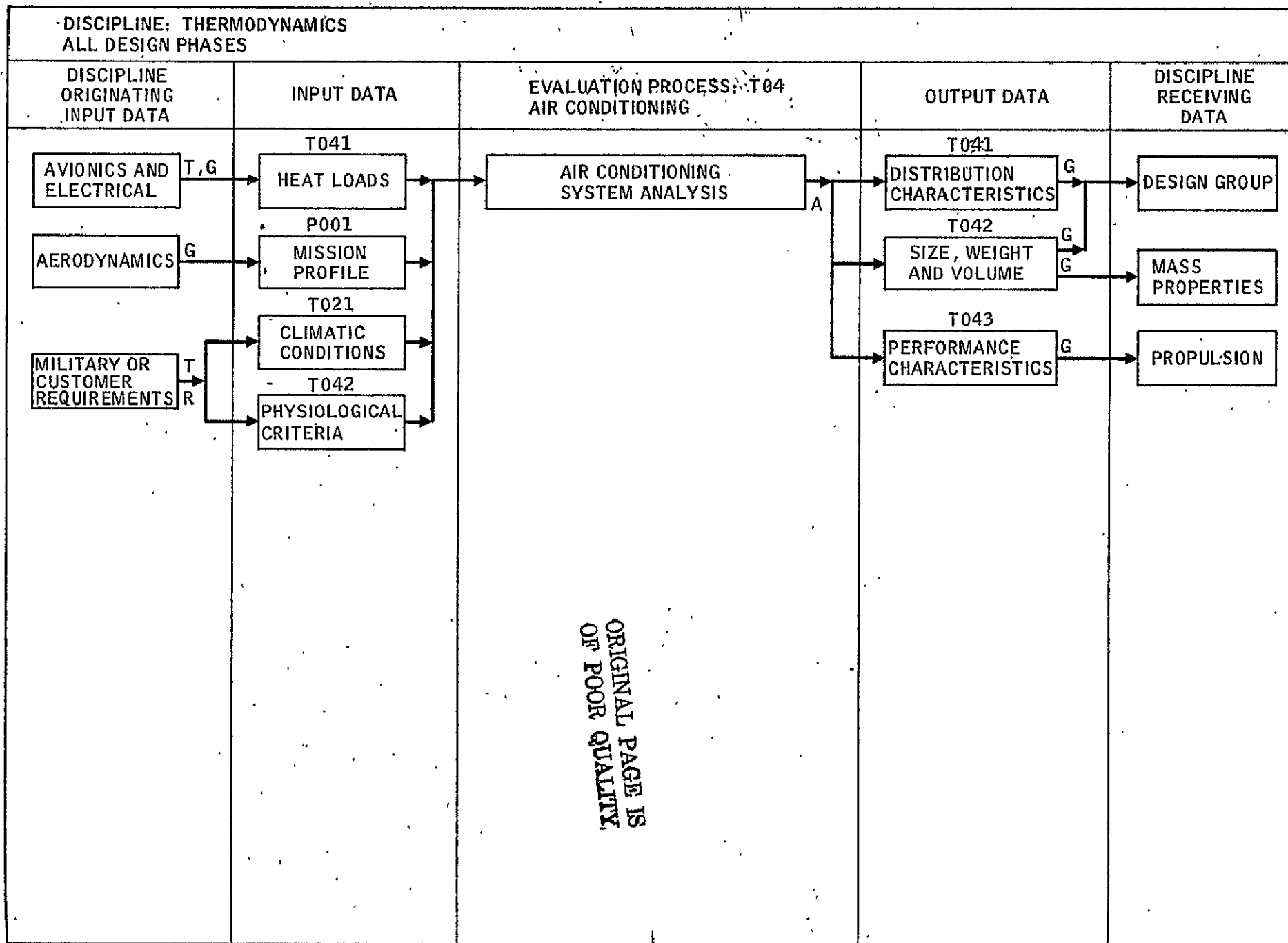


Figure 3-48. Air Conditioning

TABLE 3-6. MASS PROPERTIES CEP'S AND COMPUTER PROGRAMS

TASKS	CEP	Design Phase		
		C	PD	DD
Define configuration geometry	W01	x	x	
Estimate preliminary gross weight	W02	x	x	
Develop weight equations for specific configuration	W03	x	x	
Define weights in parametric terms	W04	x	x	
Develop weight/size versus fuel relationships	W05	x	x	
Estimate weights for point design	W06	x	x	
Develop mass properties characteristics and refine weights	W07	x	x	
Determine effect of trade studies on mass properties	W08	x	x	
Update weights, size, geometry, etc., to reflect effect of trade studies	W09		x	
Minimize weight	W10		x	x
Estimate detailed weights	W11		x	x
Develop detailed balance and loading data	W12		x	x
Detailed mass distribution and inertias	W13		x	x
Weight penalties due to A/C features	W14		x	x
Cost elements	W15		x	x
Weight substantiation	W16		x	x
<u>COMPUTER PROGRAMS</u>				
P5525 Aircraft weight sizing		x	x	
P5619 Aircraft inertia (MIPI)		x	x	
P5619 Aircraft mass distribution		x	x	x
P5152 Aircraft weight, C.G., cost element tabulation			x	x
Parts count				x

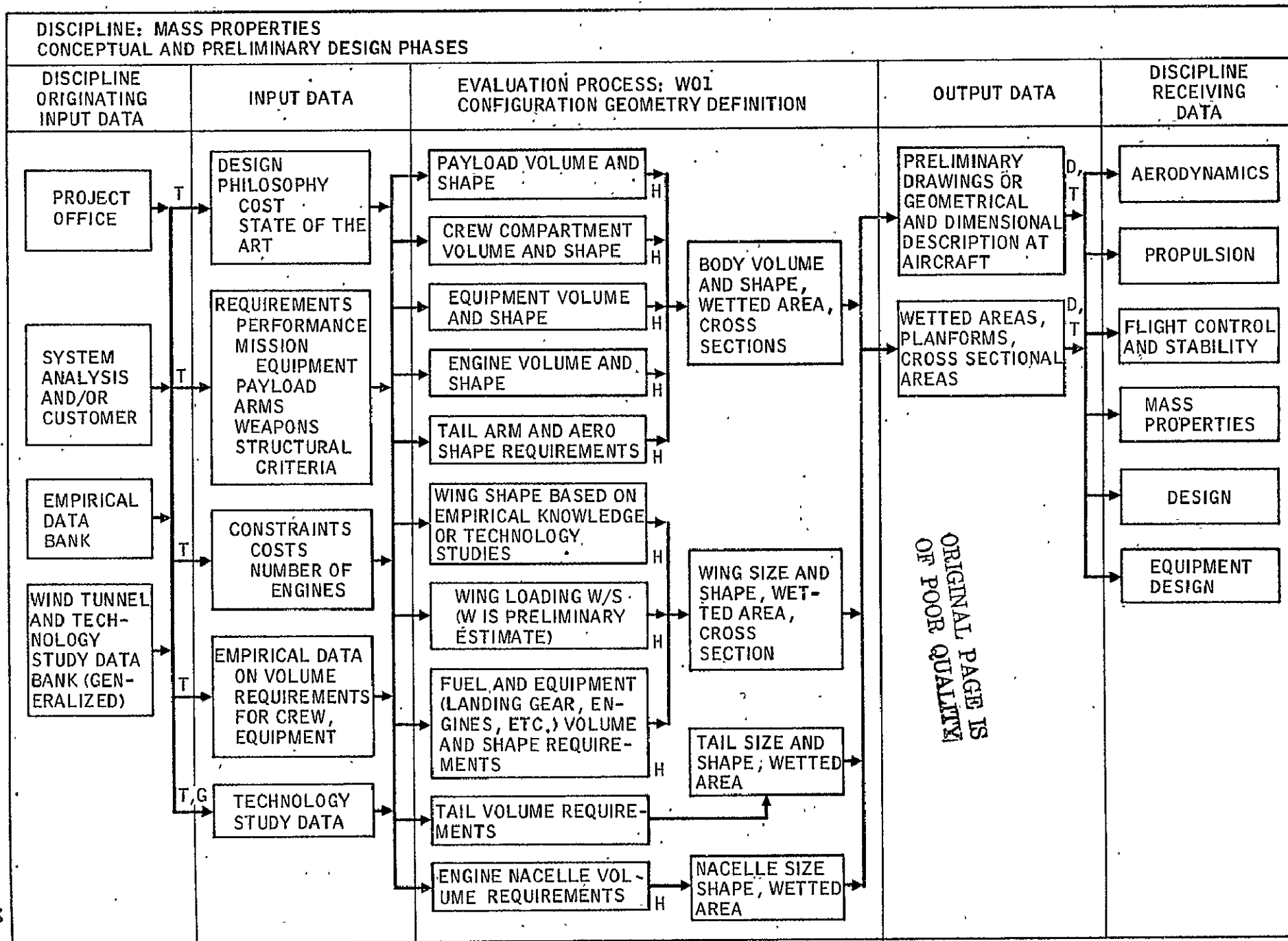
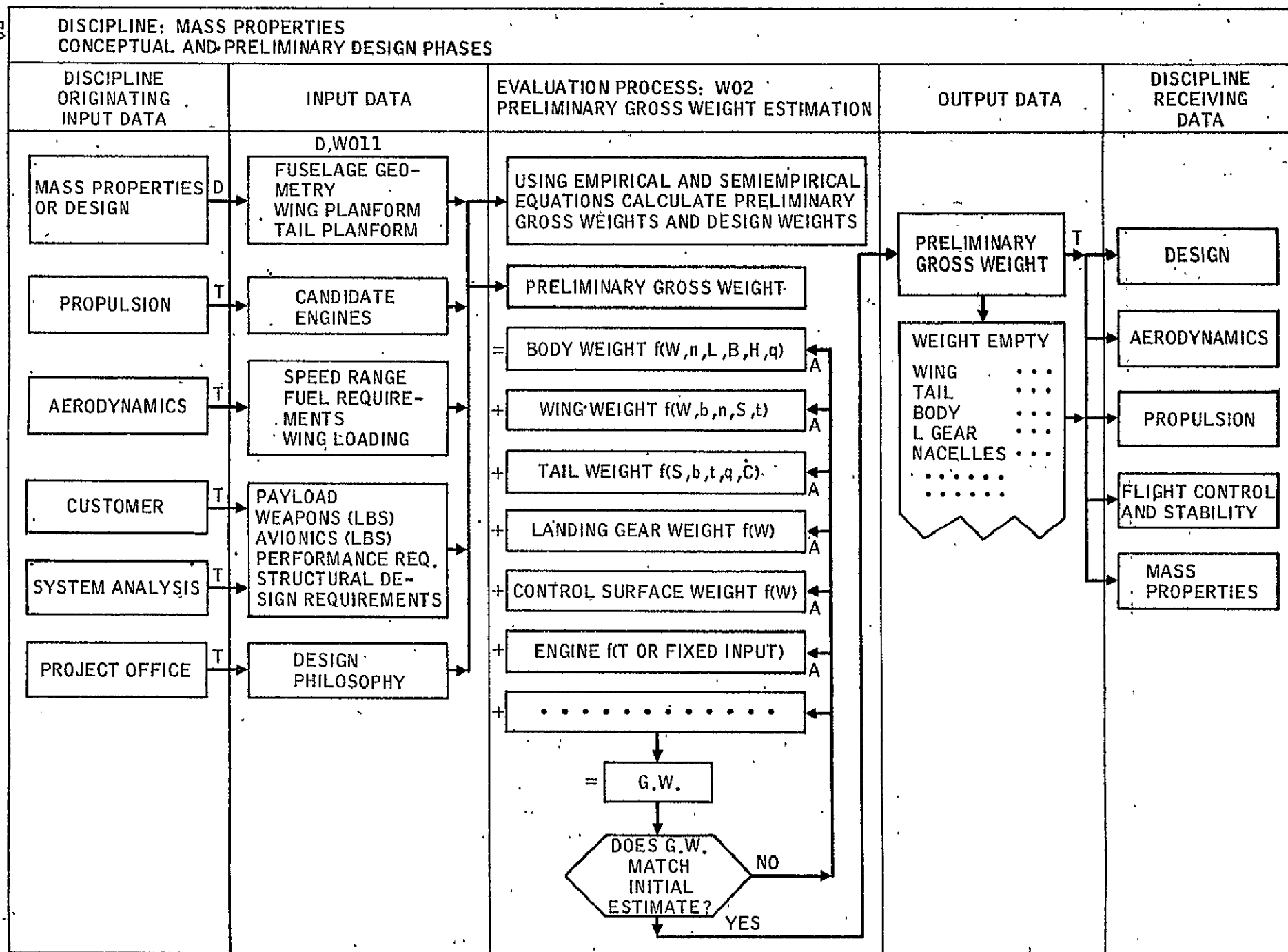
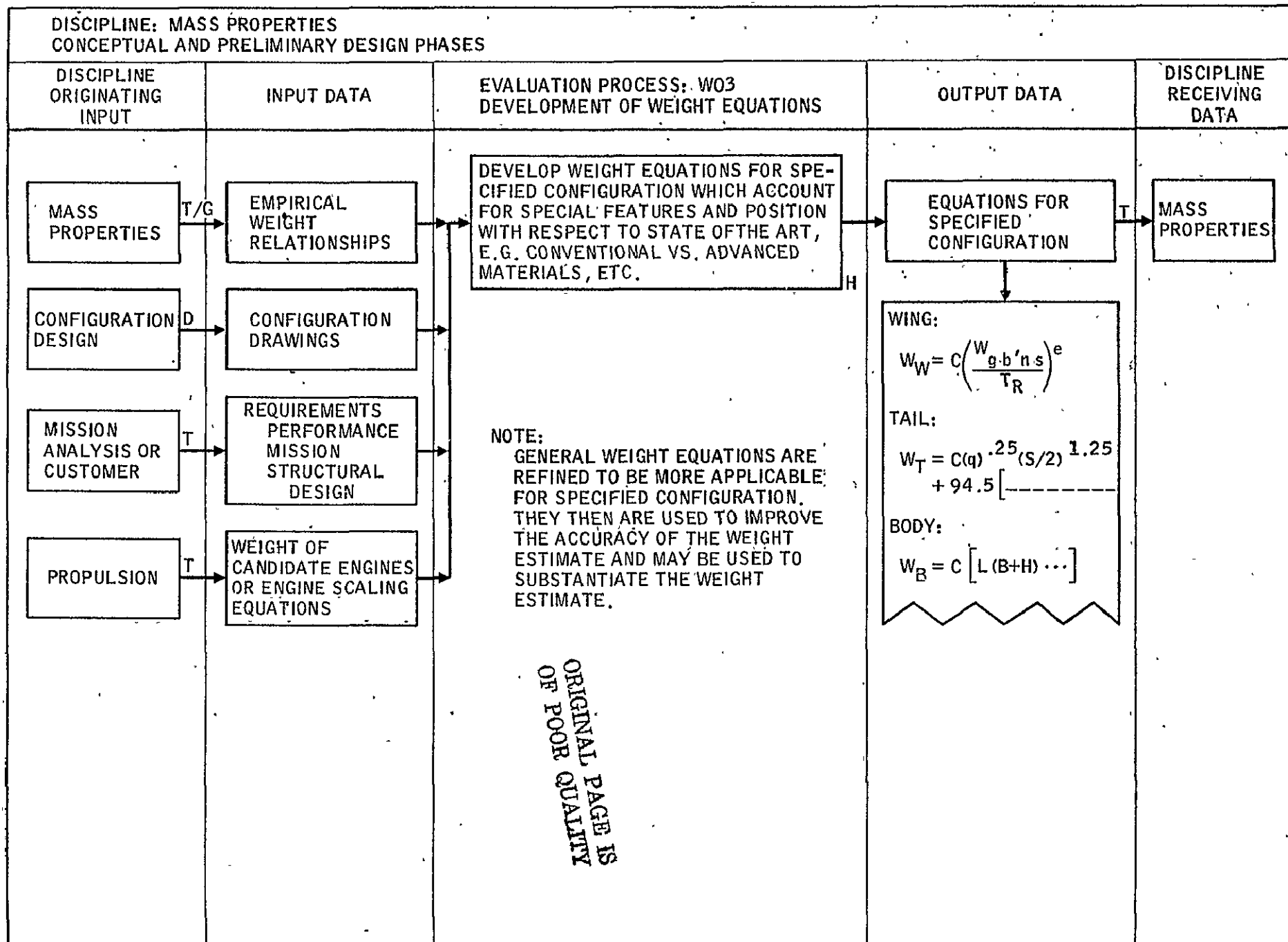


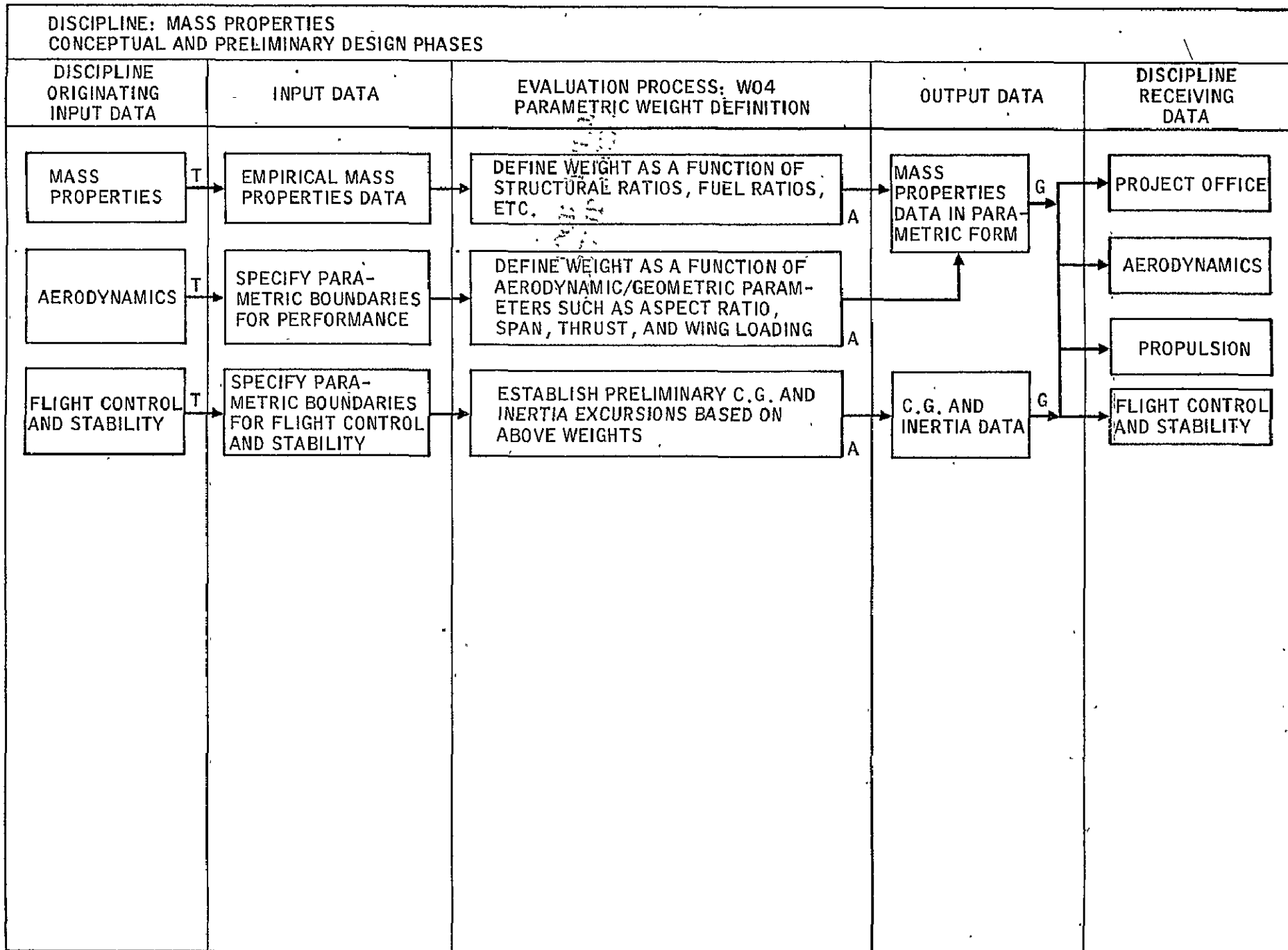
Figure 3-49. Configuration Geometry Definition

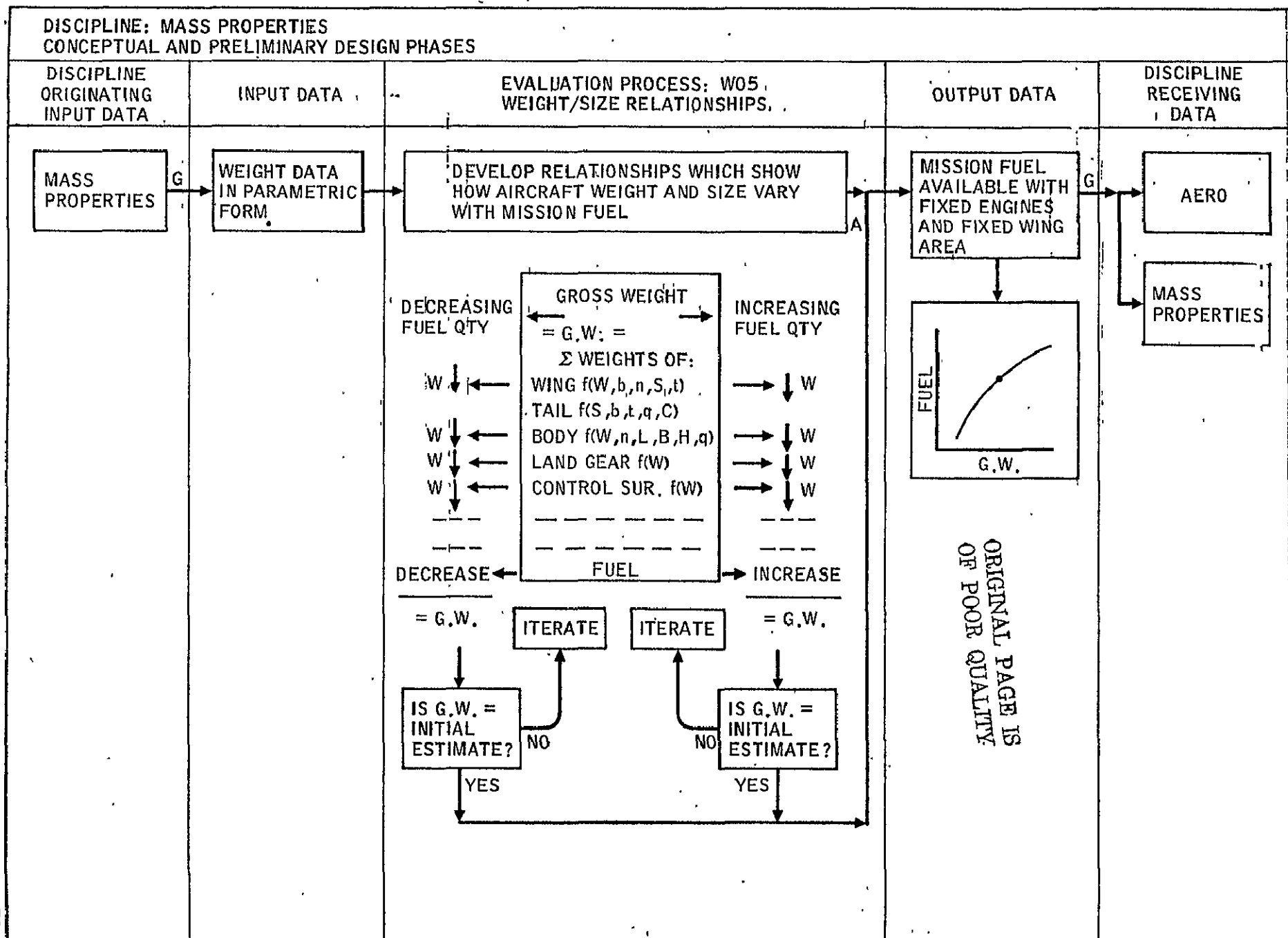




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Figure 3-51. Development of Weight Equations

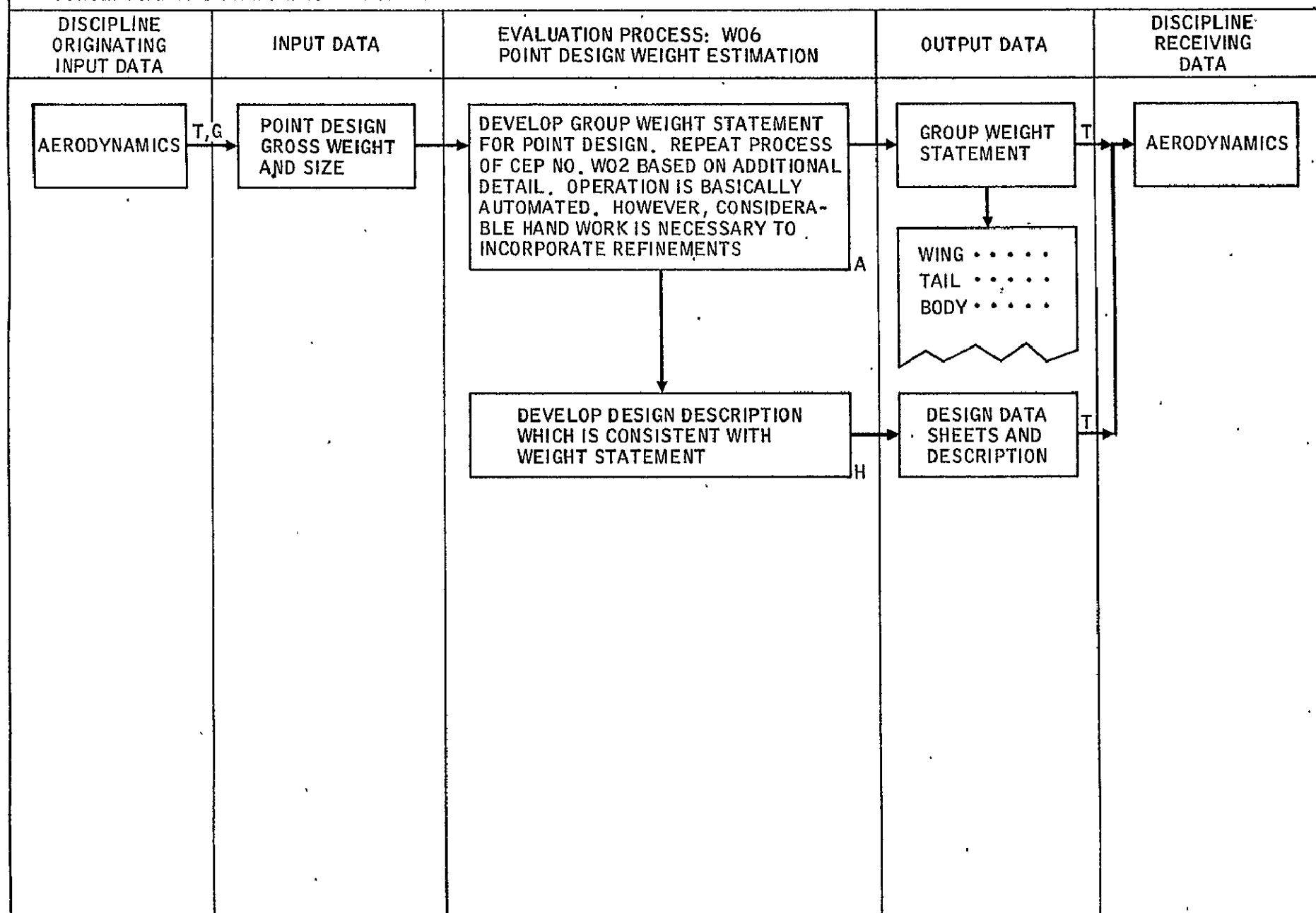




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Figure 3-53. Weight/Size Relationships

DISCIPLINE: MASS PROPERTIES
CONCEPTUAL AND PRELIMINARY DESIGN PHASES



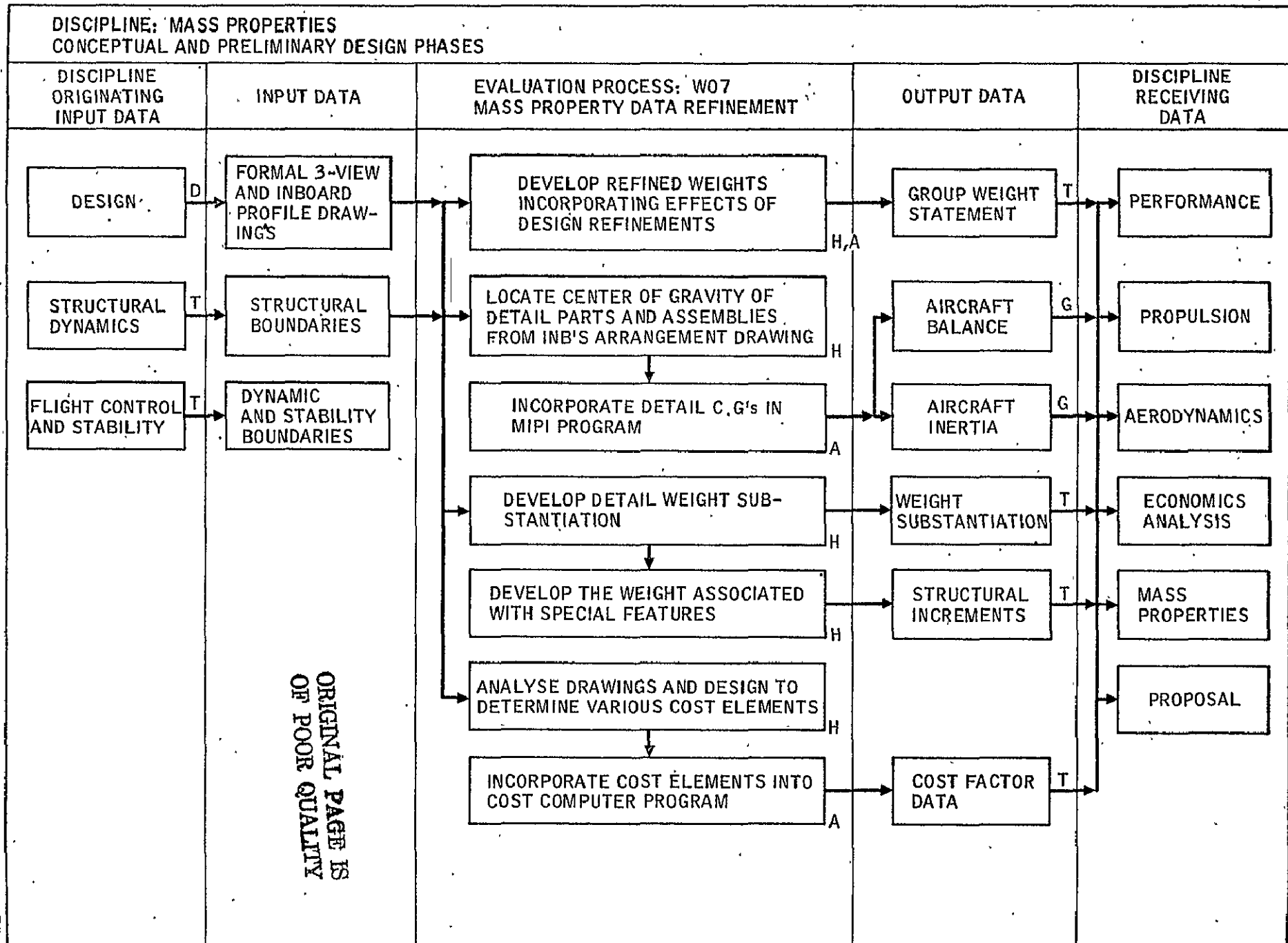
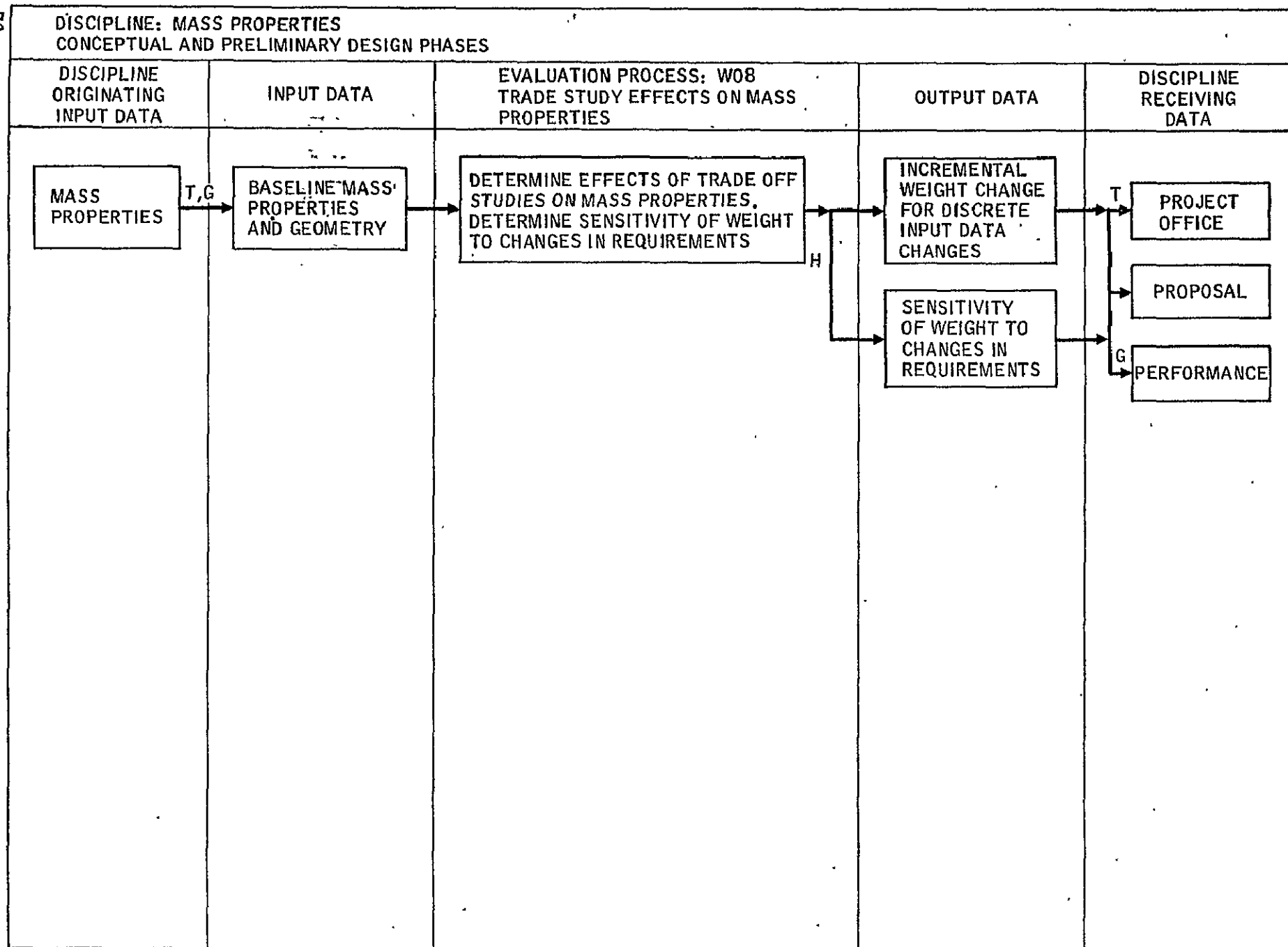


Figure 3-55. Mass Property Data Refinement



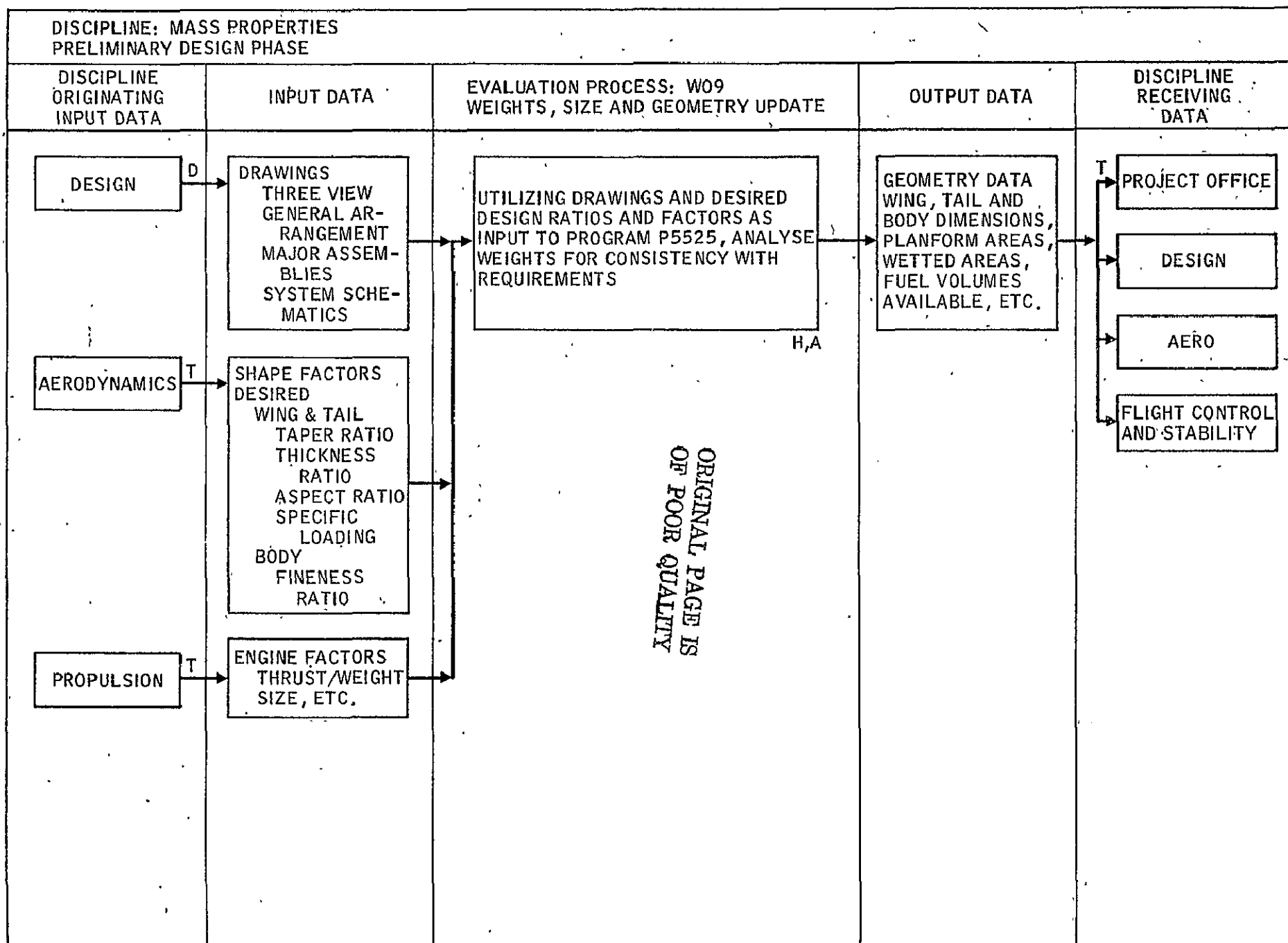
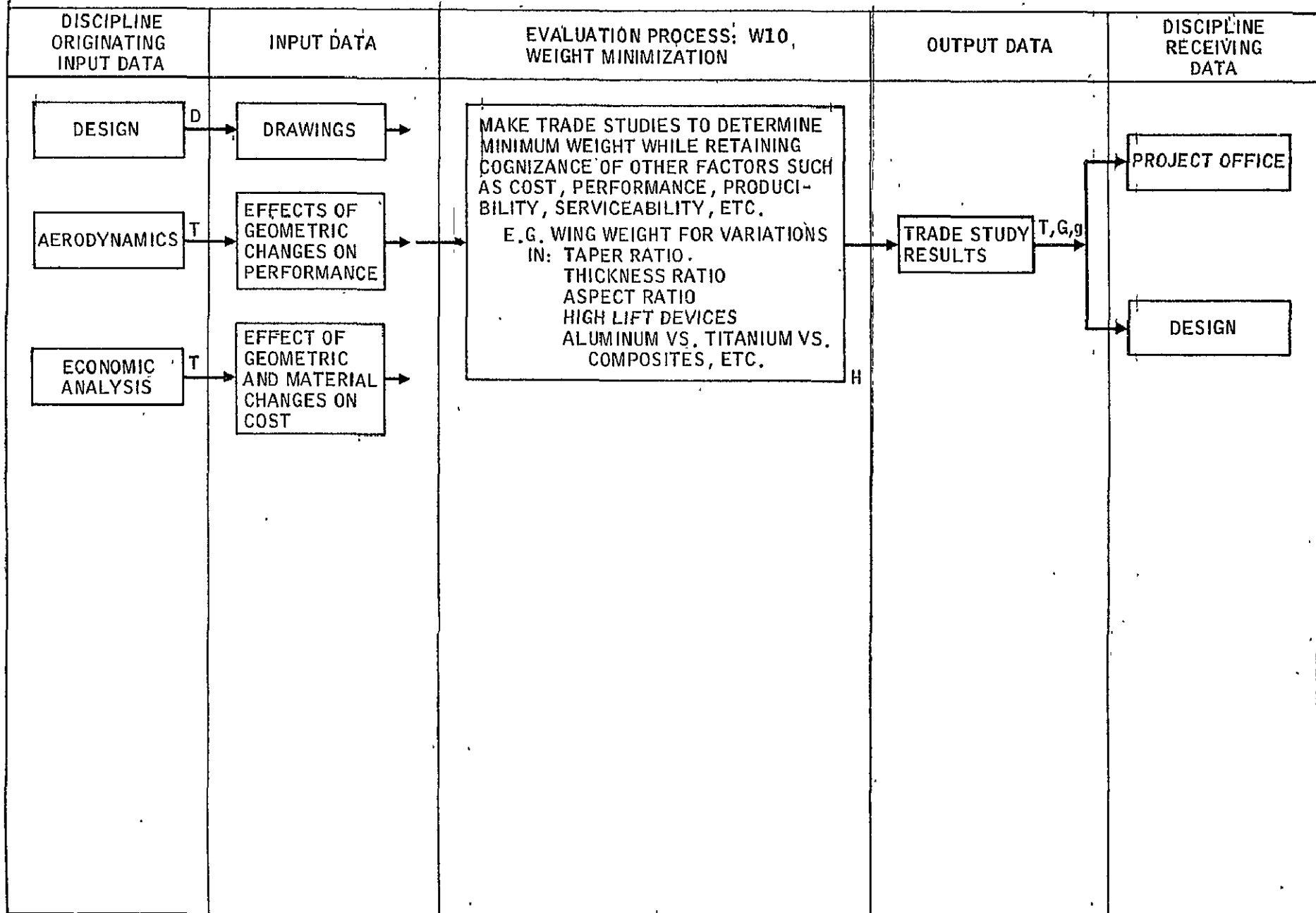


Figure 3-57. Weights, Size, and Geometry Update

DISCIPLINE: MASS PROPERTIES
PRELIMINARY AND DETAILED DESIGN PHASES



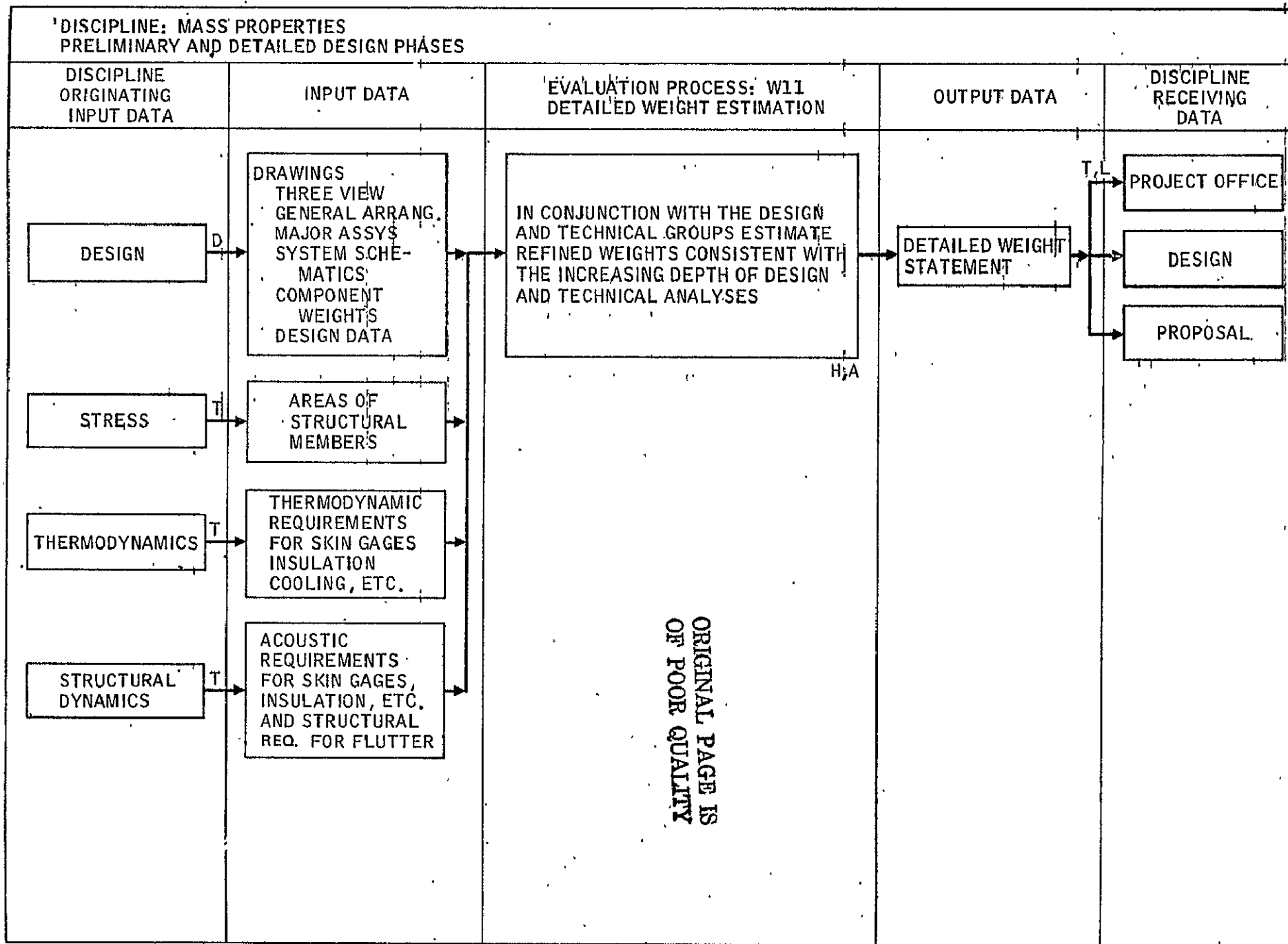
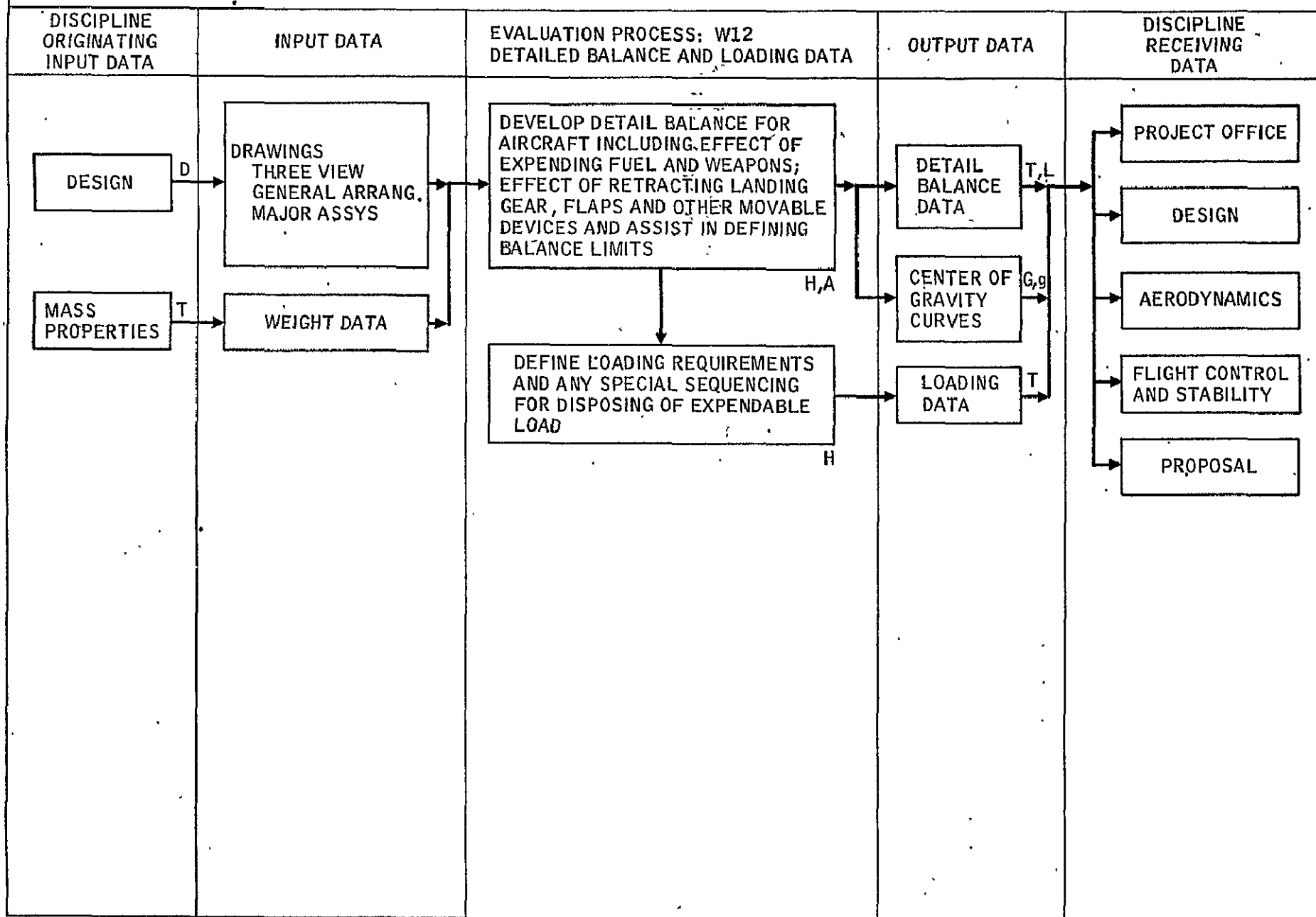


Figure 3-59. Detailed Weight Estimation

DISCIPLINE: MASS PROPERTIES
PRELIMINARY AND DETAILED DESIGN PHASES



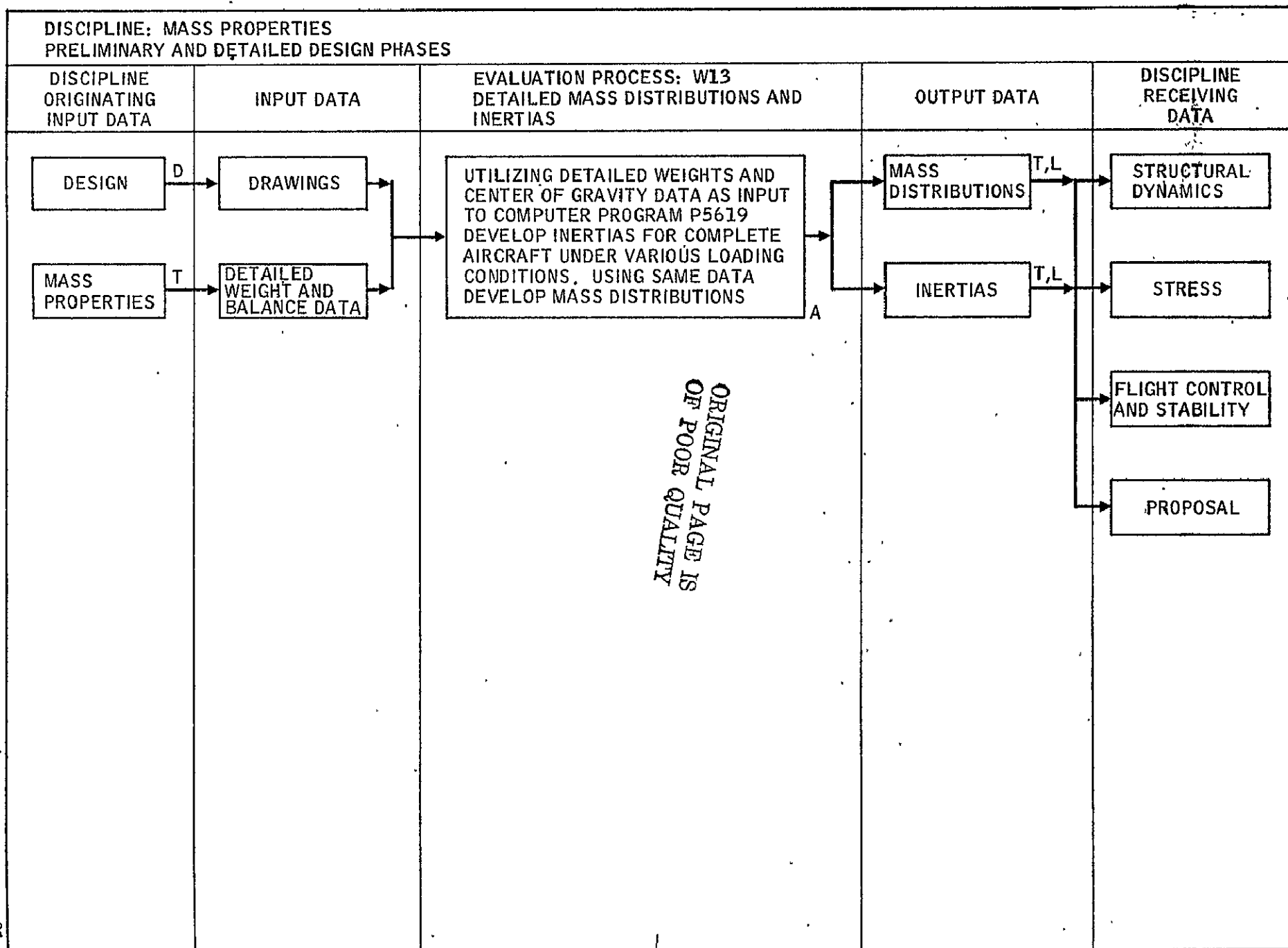
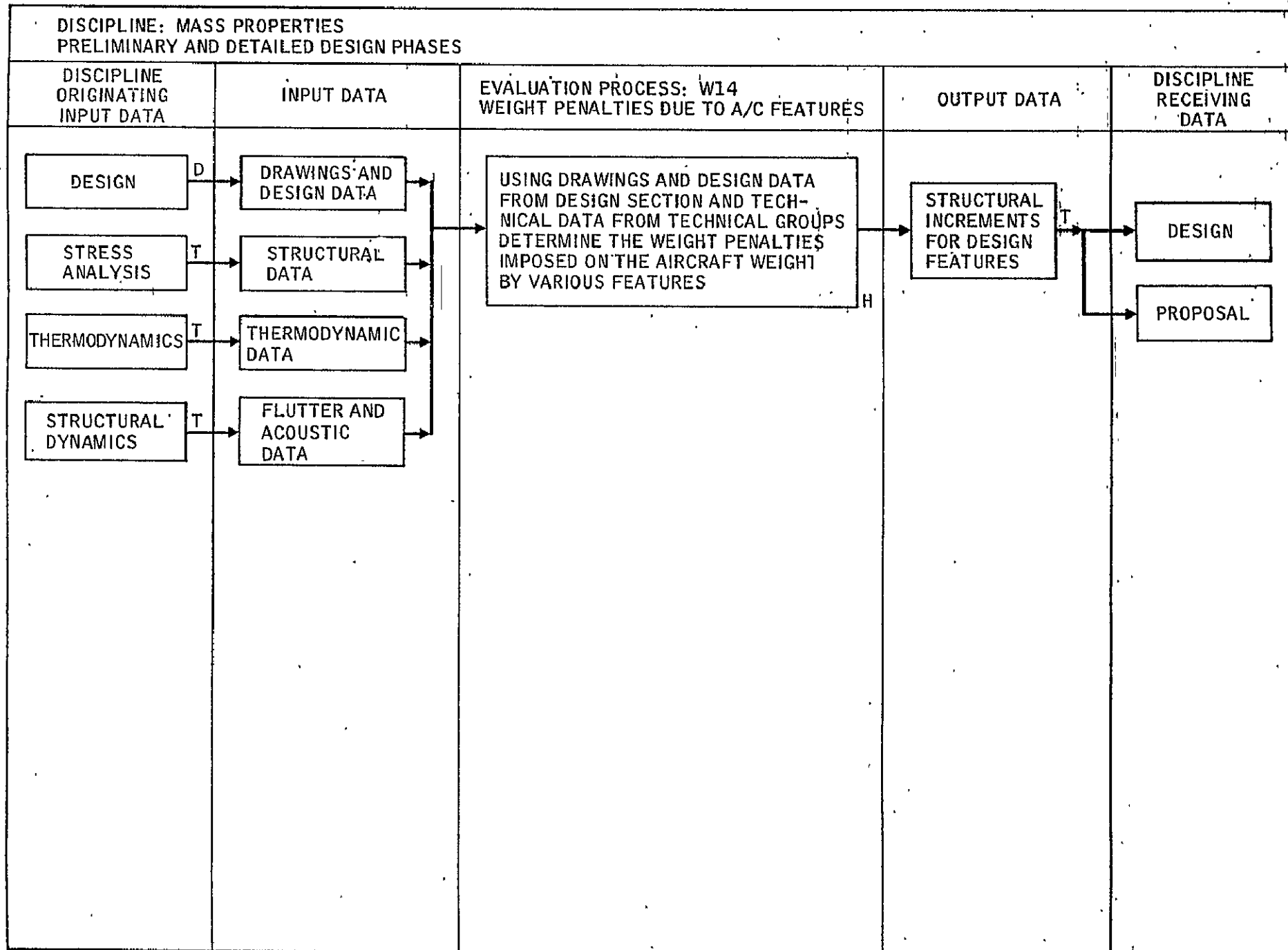


Figure 3-61. Detailed Mass Distributions and Inertias



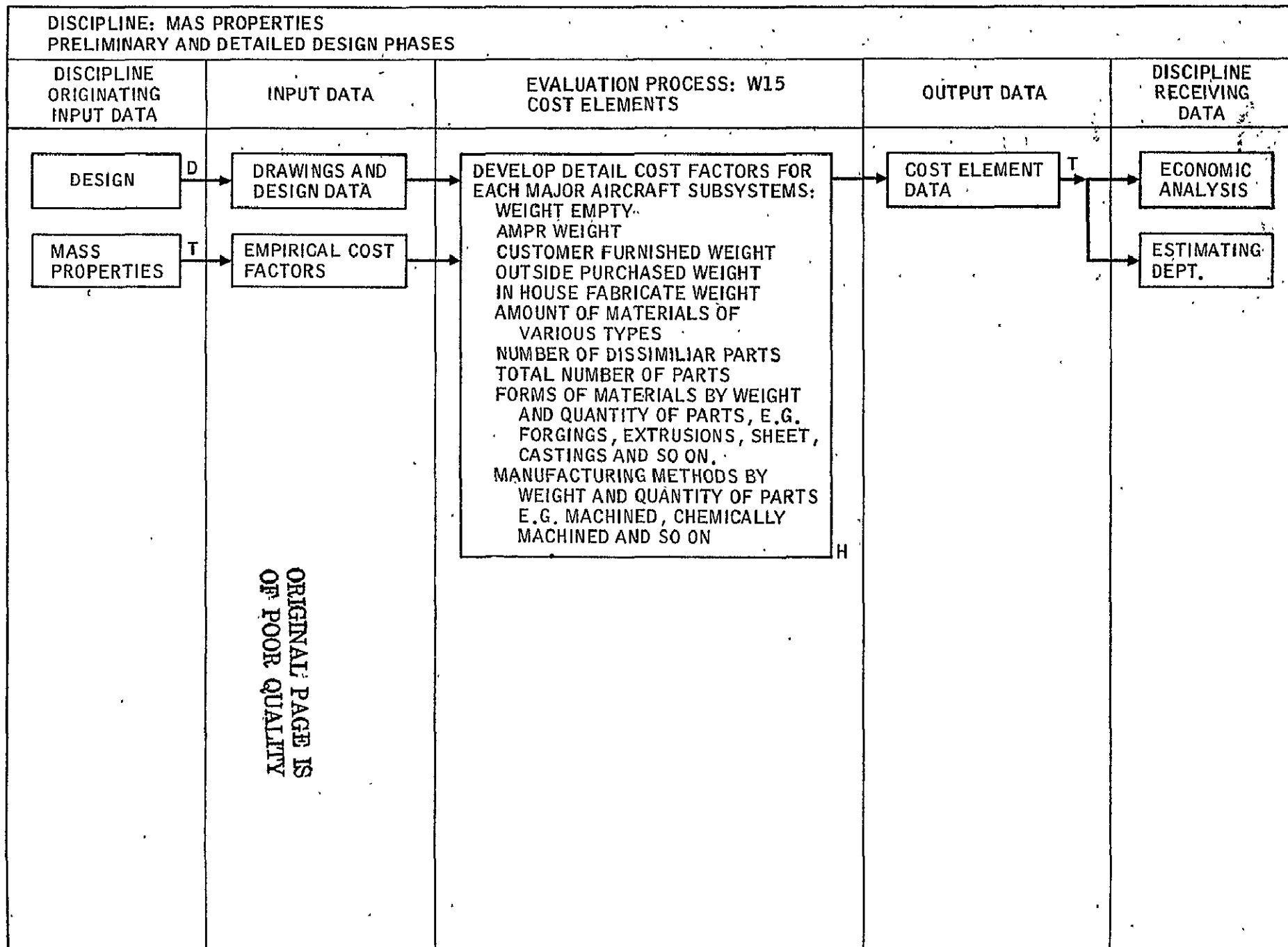
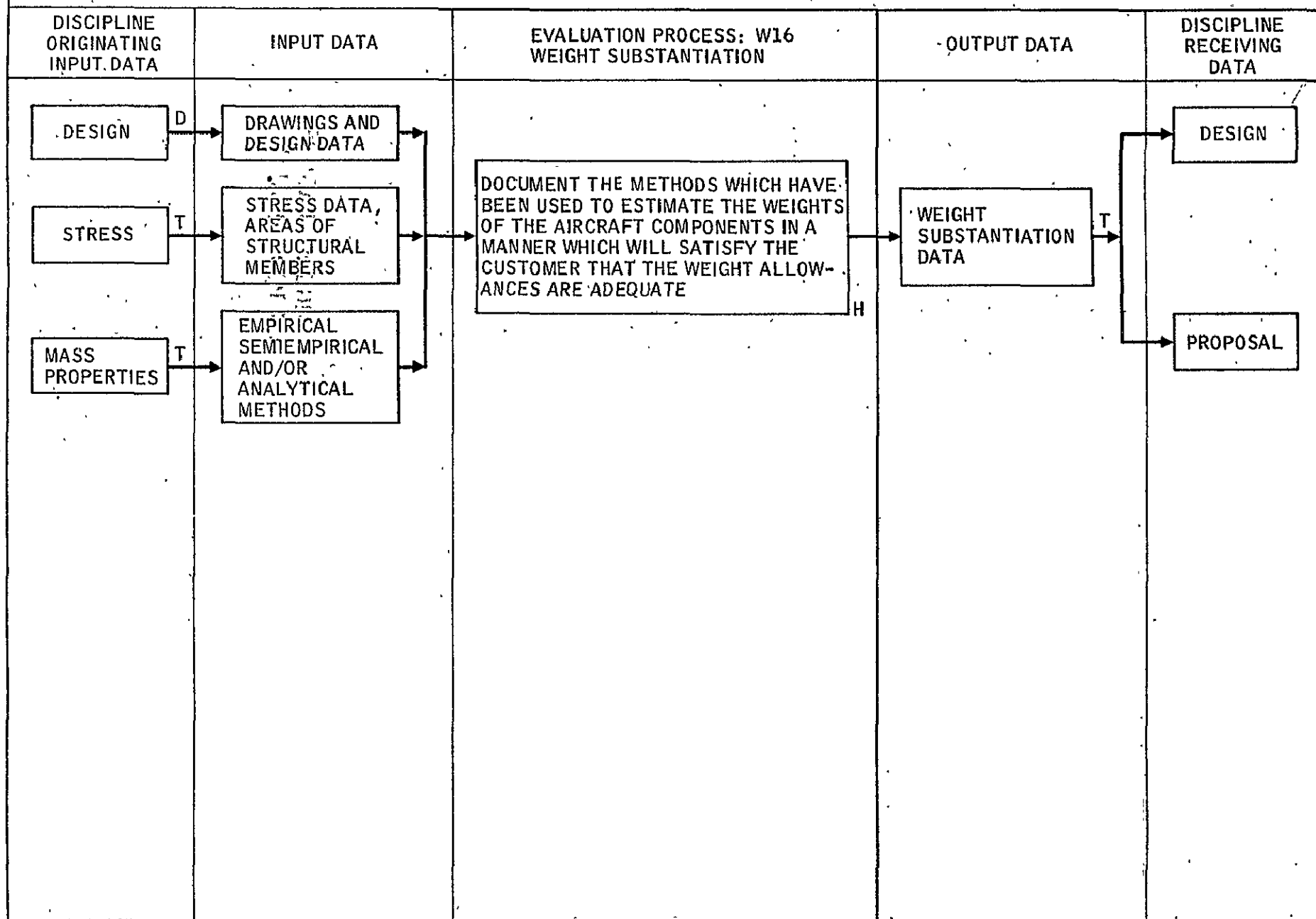


Figure 3-63. Cost Elements

DISCIPLINE: MASS PROPERTIES
PRELIMINARY AND DETAILED DESIGN PHASES



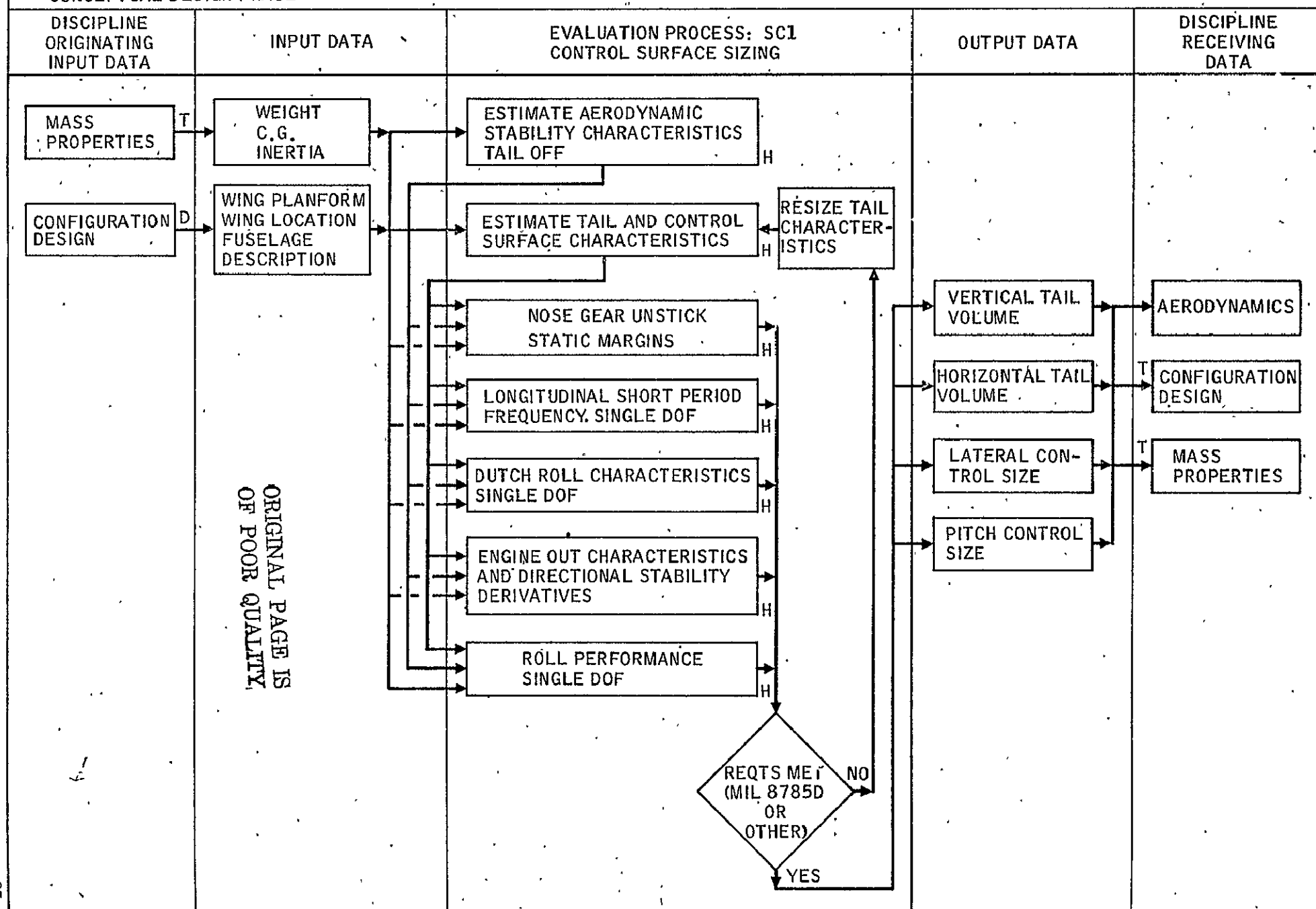


Figure 3-65. Control Surface Sizing

TABLE 3-7. FLIGHT CONTROL AND STABILITY CEP'S AND COMPUTER PROGRAMS

TASKS	CEP	Design Phase		
		C	PD	DD
Mechanical Flight Control System Design			x	x
Automatic Flight Control System Design			x	x
Basic Aircraft Stability Analysis	SC1	x	x	x
Control Surface Requirements Specification	SC1	x	x	x
Vertical and Horizontal Tail Sizing	SC1	x	x	
Control System Analysis	SC2		x	x
Catapult Performance Analysis	SC4	x	x	x
Stores Separation Analysis	SC5		x	x
Six Degree-of-Freedom Trajectory Analysis	SC6	x	x	x
Aerodynamic Stability Derivative Generation	SC1	x	x	x
Propulsive Control Requirements Specification	SC1	x	x	x
Sensor Requirements Specifications	-		x	x
Flight Control Simulation	SC3	x	x	x
<u>COMPUTER PROGRAMS</u>				
TRIM-STAB General Analysis of Control Systems Evaluates Pertinent System Characteristics	SC2	x	x	x
LAUNCH Simulates the Launch or Flight of a Missile or Booster During Launch. Determines Control System Requirements.	SC6		x	x
CATAPULT Simulates the Catapult Launch of an Aircraft to Evaluate Performance and Control System Requirements.	SC4		x	x
3270 General Differential Equation Solver. Equations in Laplace Notation.			x	x

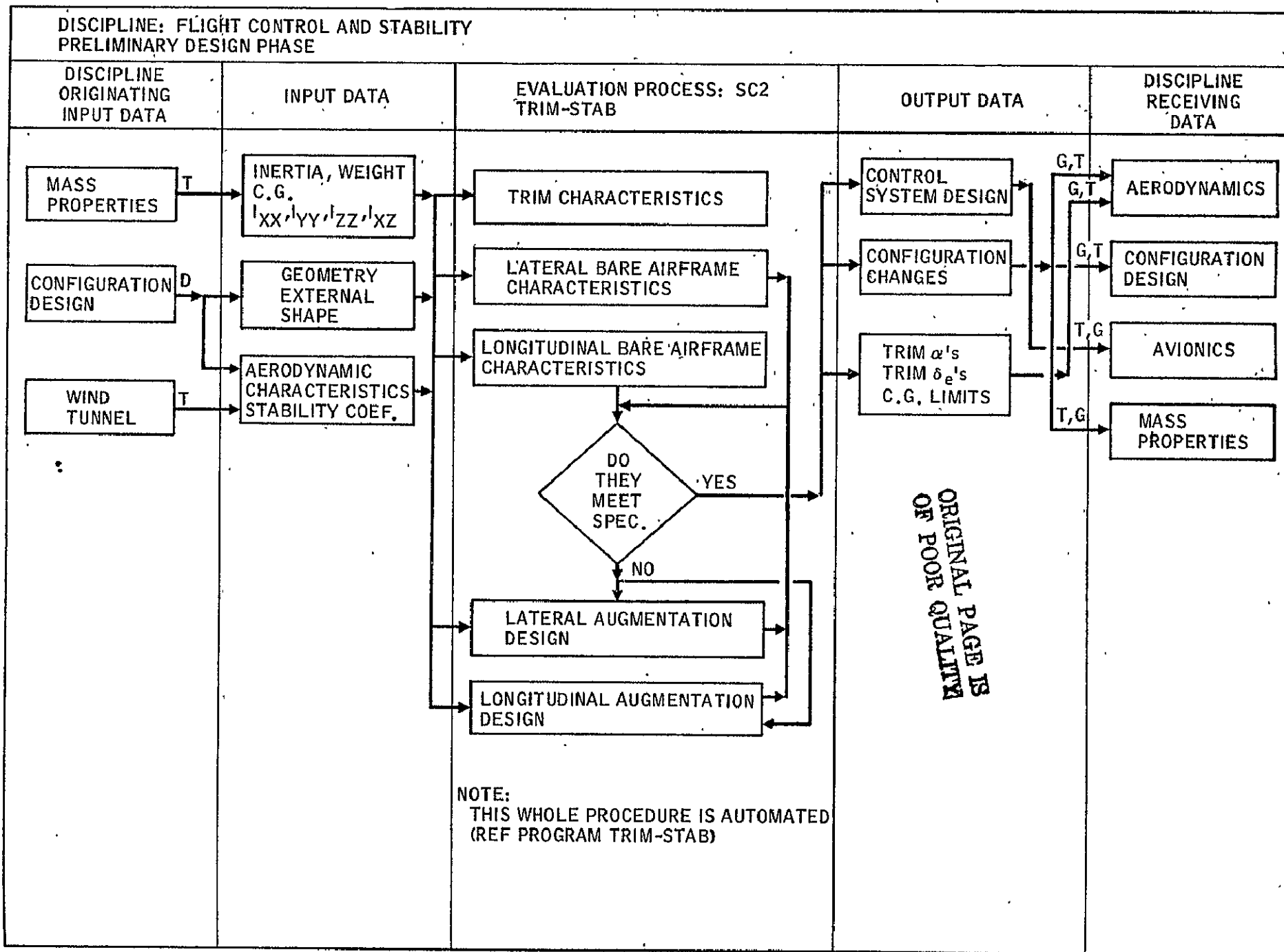
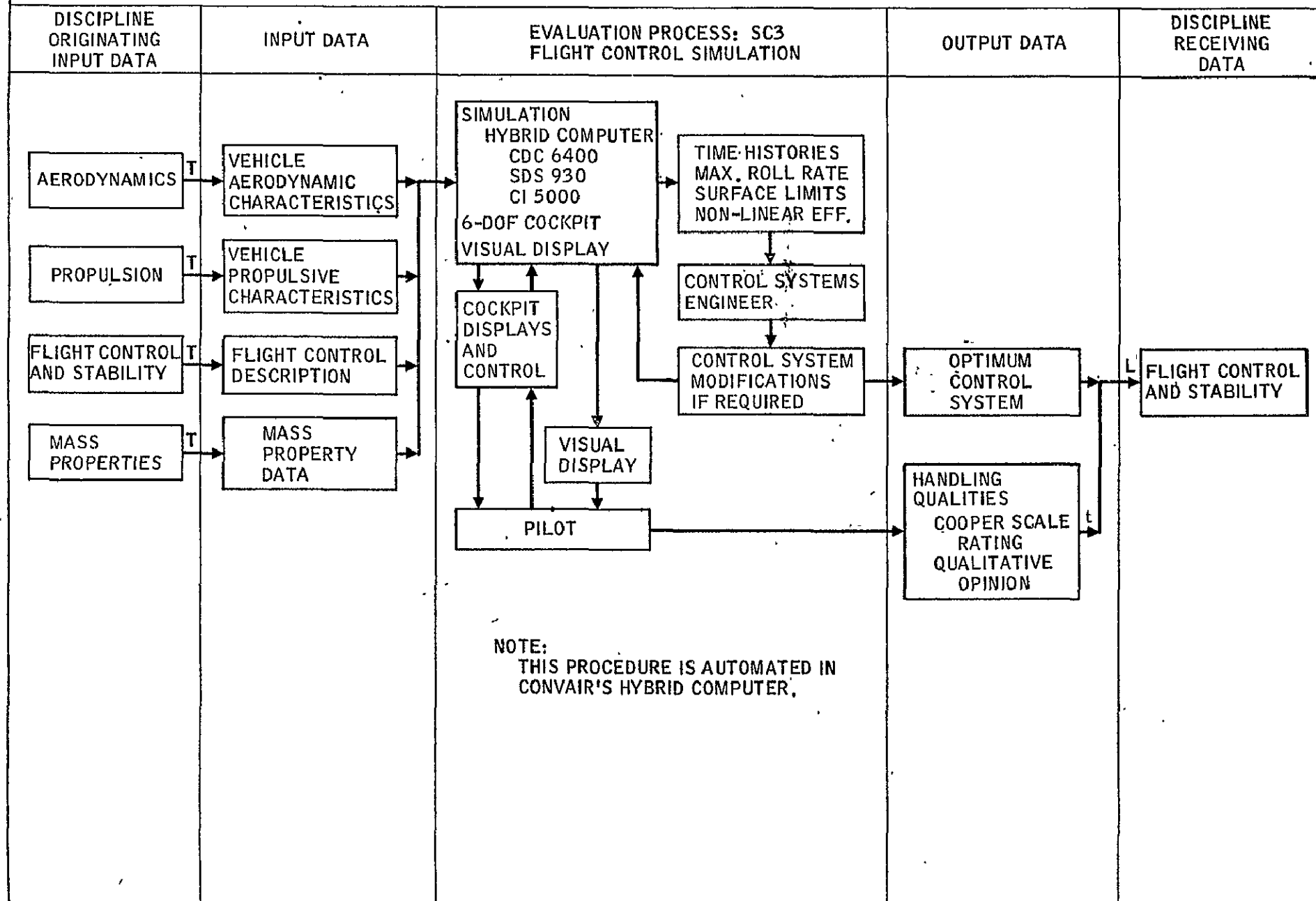


Figure 3-66. Program TRIM-STAB

DISCIPLINE: FLIGHT CONTROL AND STABILITY
ALL DESIGN PHASES



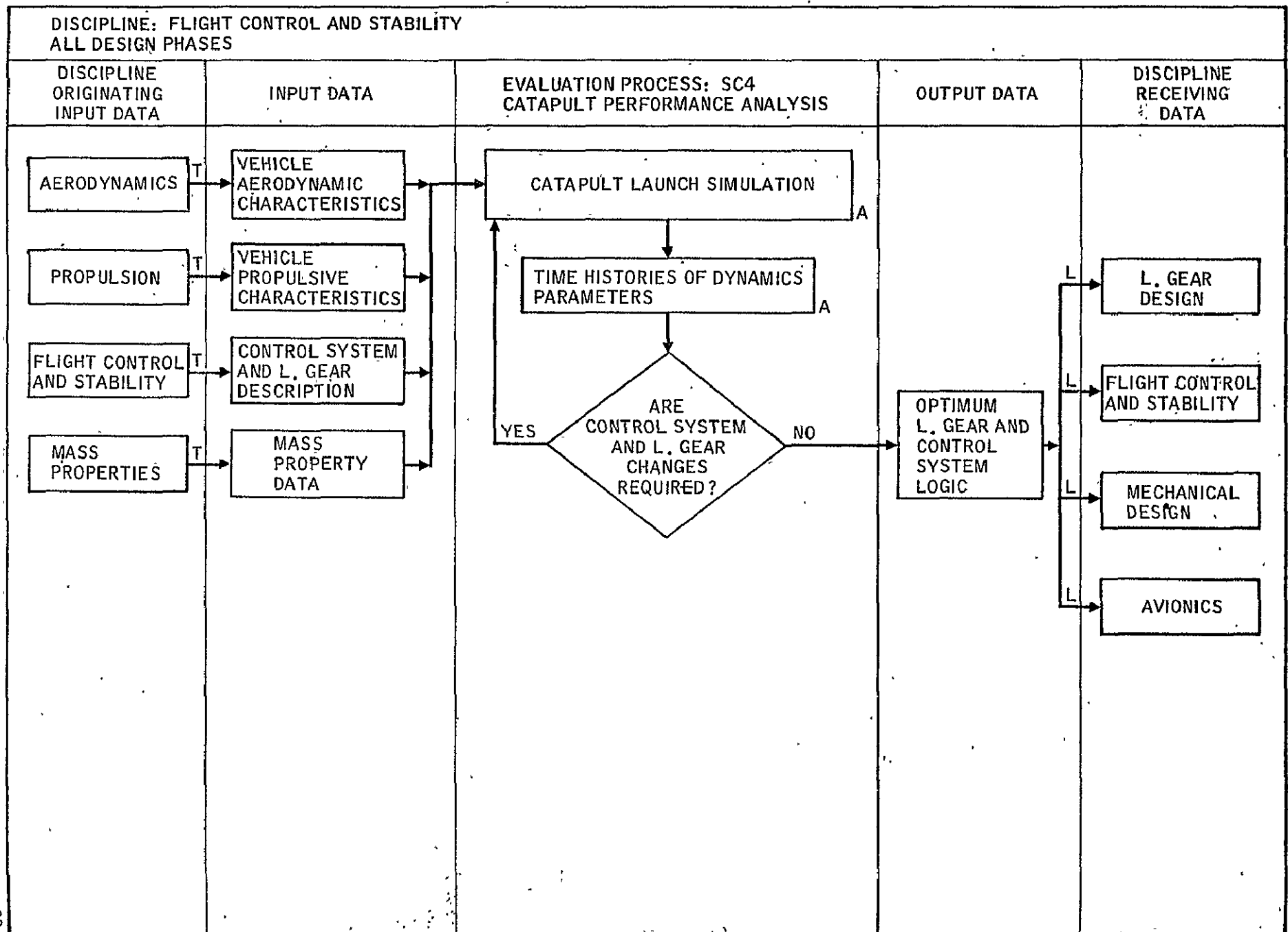
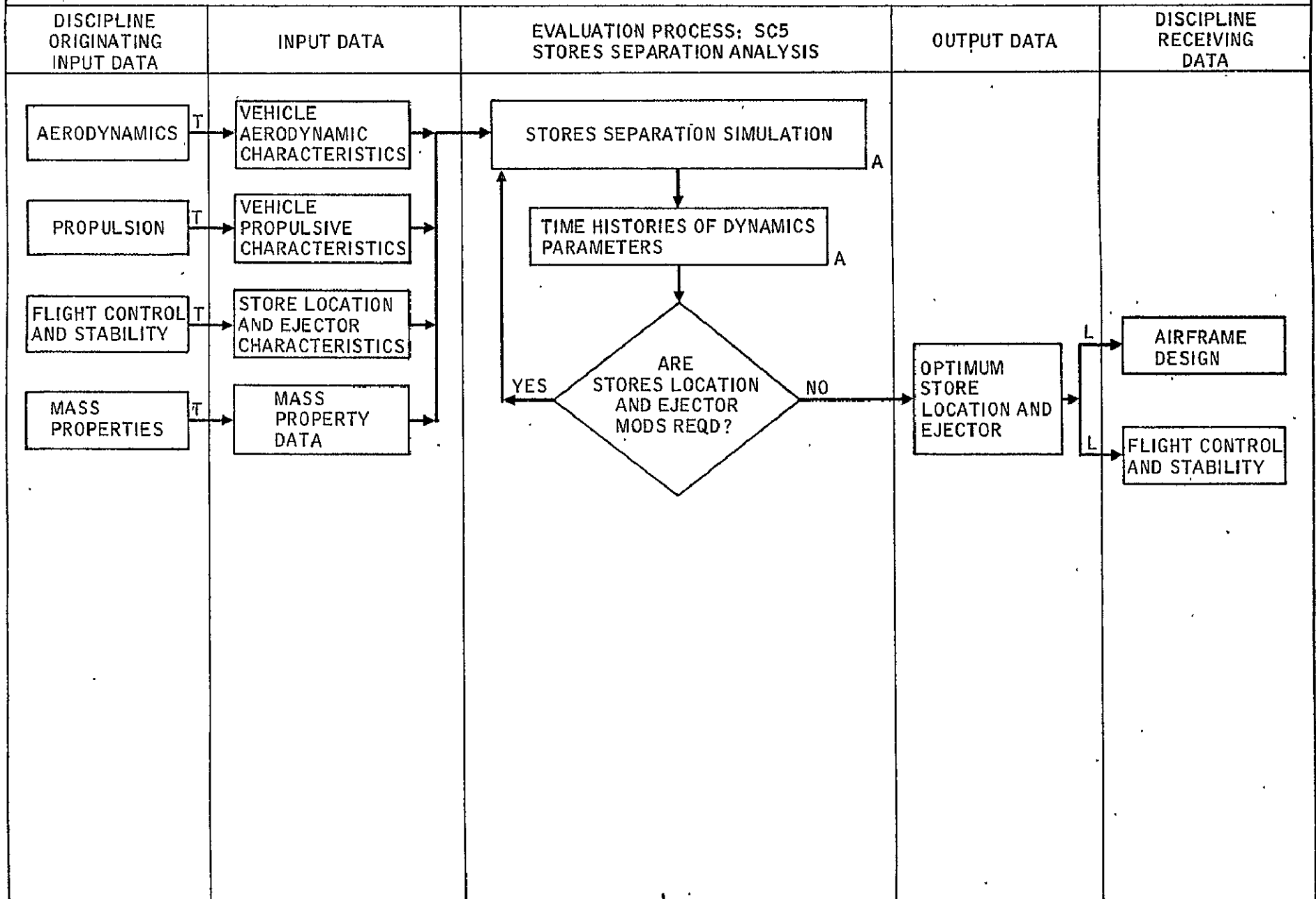


Figure 3-68. Catapult Performance Analysis

DISCIPLINE: FLIGHT CONTROL AND STABILITY
PRELIMINARY AND DETAILED DESIGN PHASES



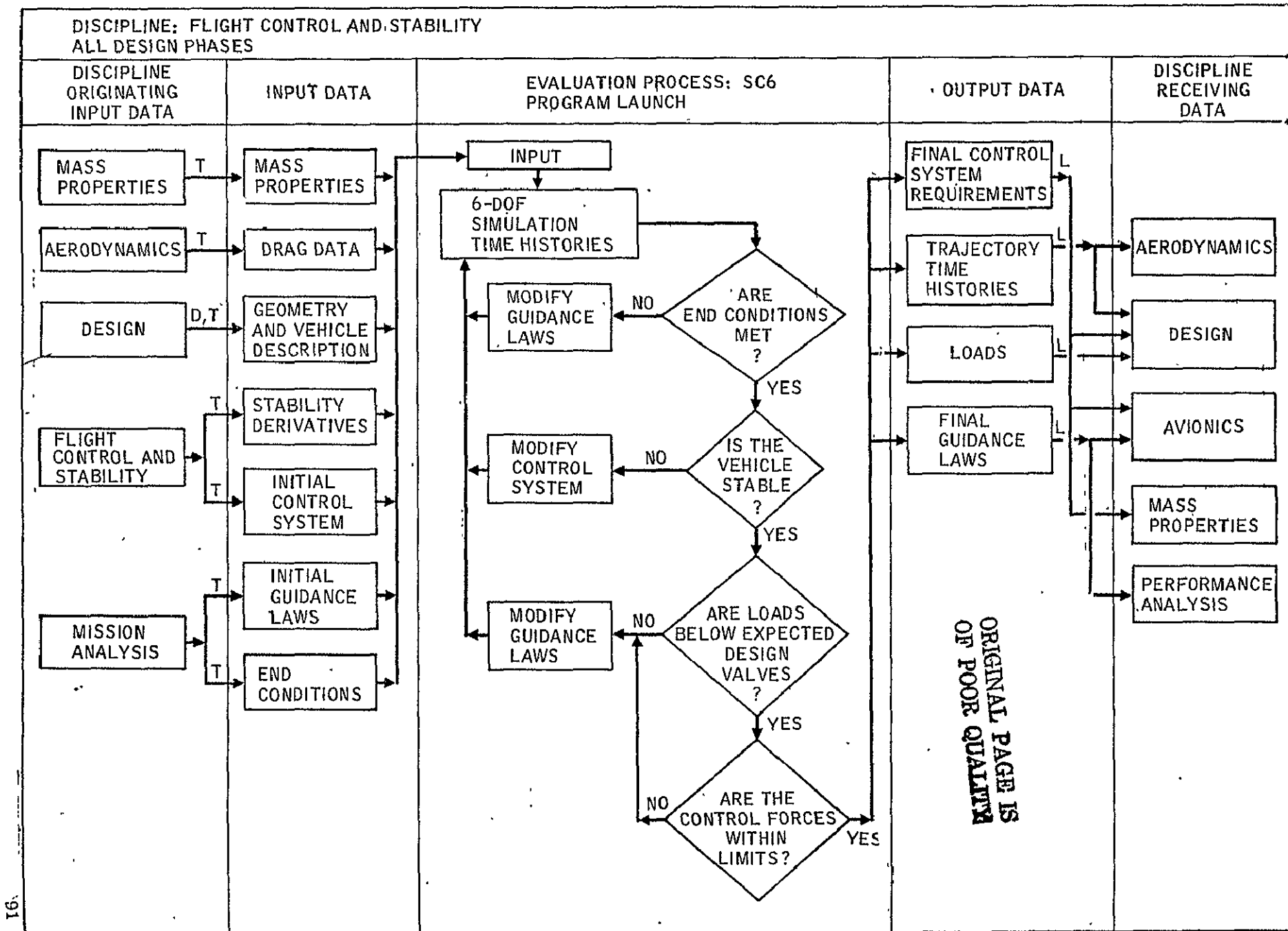


Figure 3-70. Program LAUNCH

TABLE 3-8. OPERATIONS RESEARCH CEP'S AND COMPUTER PROGRAMS

TASKS	CEP	Design Phase		
		C	PD	DD
Mission Effectiveness Simplified manual definition of mission, derivation of mathematical model of mission performance, and hand computation of airplane effectiveness in that mission. Typical measure of effectiveness is the number of airplanes required to accomplish a fixed task.	OR1	x		
Transport Mission Effectiveness Determines transport fleet size required to serve specified route system and tonnages.	OR2		x	
Tactical Mission Effectiveness Determination Simulation of aircraft operation in a tactical environment.	OR3		x	x
Strategic Mission Effectiveness Determination Simulation of aircraft operation in a strategic environment.	OR4		x	x
Preliminary Basing and Operations Analysis Estimation of support requirements (e.g., tankers, maintenance, spares, personnel) implied by proposed basing scheme.	OR5		x	
Availability Analysis Simulation of maintenance and operations of a wing of aircraft to determine turnaround time-distribution, maximum sortie rates and alert rates.	OR6		x	x
Support Assets Determination Determination of spares, AGE, and personnel required to sustain an operating unit of aircraft under various circumstances.	OR7		x	

TABLE 3-8. OPERATIONS RESEARCH CEP'S AND COMPUTER PROGRAMS (CONT'D).

TASKS	ORIGINAL PAGE IS OF POOR QUALITY	CEP	Design Phase		
			C	PD	DD
Preliminary Survivability Evaluation		OR8	x		
Estimation of probabilities of survival for single encounters with various threat types (e.g., SAMs, interceptors) as formation of performance parameters (e.g., speed, penetration altitude).					
Vulnerability/Survivability Evaluation		OR9	x		
Utilizes manual estimates of vulnerable area to rank competing candidates or as input to weapon simulation models to compute relative probabilities of survival.					
System Analysis Studies		OR10	x		
Survivability Evaluation		OR11			x
		OR12			x
Principal aircraft structural and subsystem components are represented geometrically in computer model which generates tables of vulnerable areas as function of aspect angle and kill level. Tables are then input to various weapon simulation models for computation of survival probabilities in explicit tactical situations.					
<u>COMPUTER PROGRAMS</u>					
Strategic War Model				x	
Determines targets killed and aircraft attrition for a mixed force of aircraft attacking a defended target complex.					
Penetration Simulation Model				x	x
Provides a detailed simulation of an attack on a strategic target complex by a fleet or aircraft.					

TABLE 3-8. OPERATIONS RESEARCH CEP'S AND COMPUTER PROGRAMS (CONT'D)

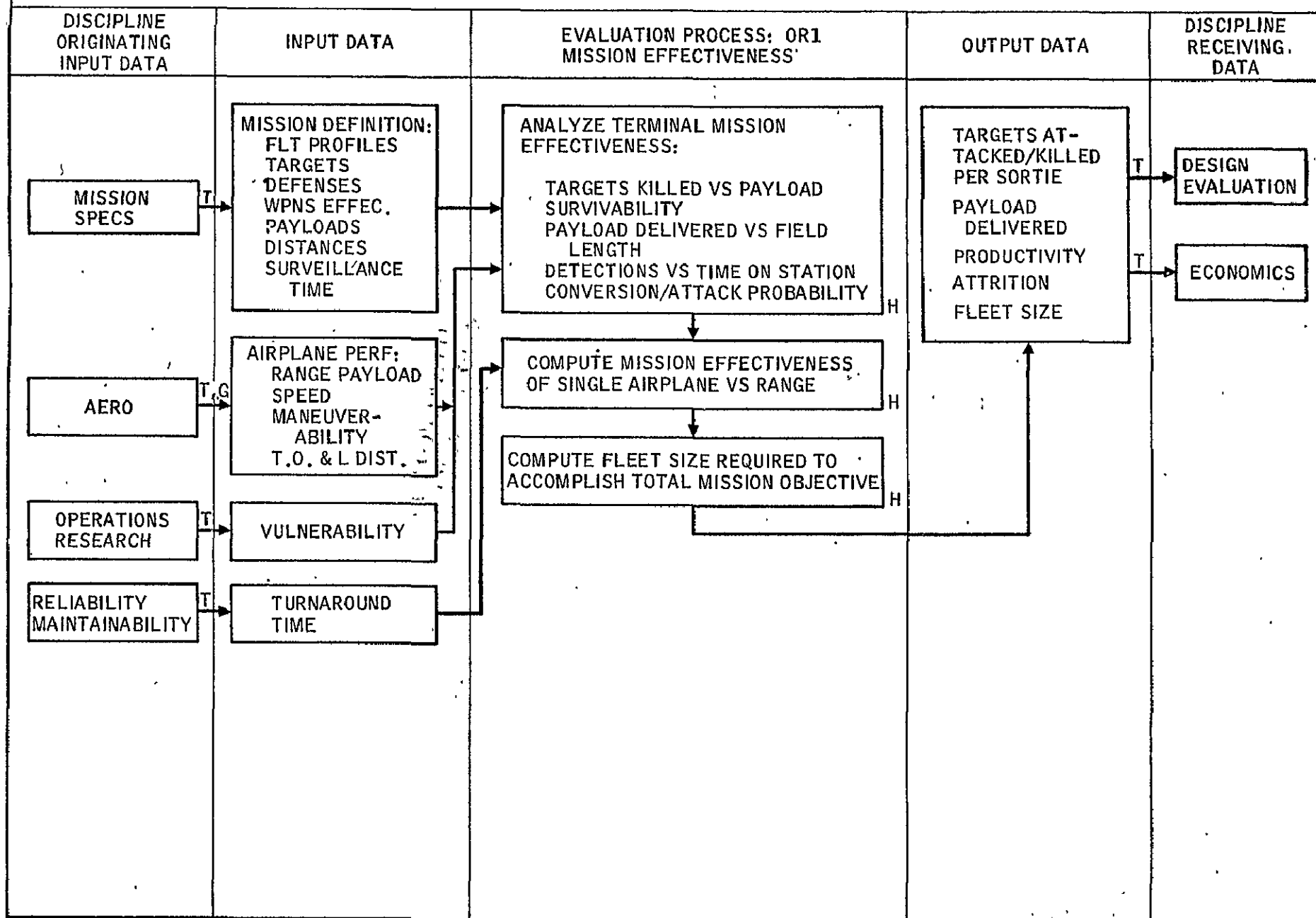
COMPUTER PROGRAMS	CEP	Design Phase		
		C	PD	DD
Cruise-Out Model Determines feasible routings for strategic aircraft and tankers from bases to penetration point.			x	x
Limited War Effectiveness Model Computes effectiveness measures (e.g., targets killed per sortie, attrition rate) for an aircraft operating in a tactical environment.		x	x	
SAM Encounter Model Simulates an encounter between an aircraft and a SAM site.		x	x	x
Air Interceptor Model Determines feasible intercept points along the flight path of an aircraft flying through a complex of interceptor bases and radar installations.		x	x	
Maneuvering Aircraft Survivability Model Dynamic simulation of maneuvering aircraft engages by antiaircraft artillery and automatic weapons.				
Subsystem Simulation Model Determines turnaround time distribution and asset requirements of each subsystem.			x	x
Network Analysis Model Determines maintenance turnaround time distribution for an aircraft.			x	x

TABLE 3-8. OPERATIONS RESEARCH CEP'S AND COMPUTER PROGRAMS (CONT'D)

COMPUTER PROGRAMS	CEP	Design Phase		
		C	PD	DD
Aircraft Vulnerability Analysis Model Aircraft structure and subsystem components are represented by large number of spatially oriented geometric shapes. Model projects shapes at desired aspect angle and computes vulnerable areas, accounting for masking effects and projectile slow down during penetration of each component.			X	X

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DISCIPLINE: OPERATIONS RESEARCH CONCEPTUAL DESIGN PHASE



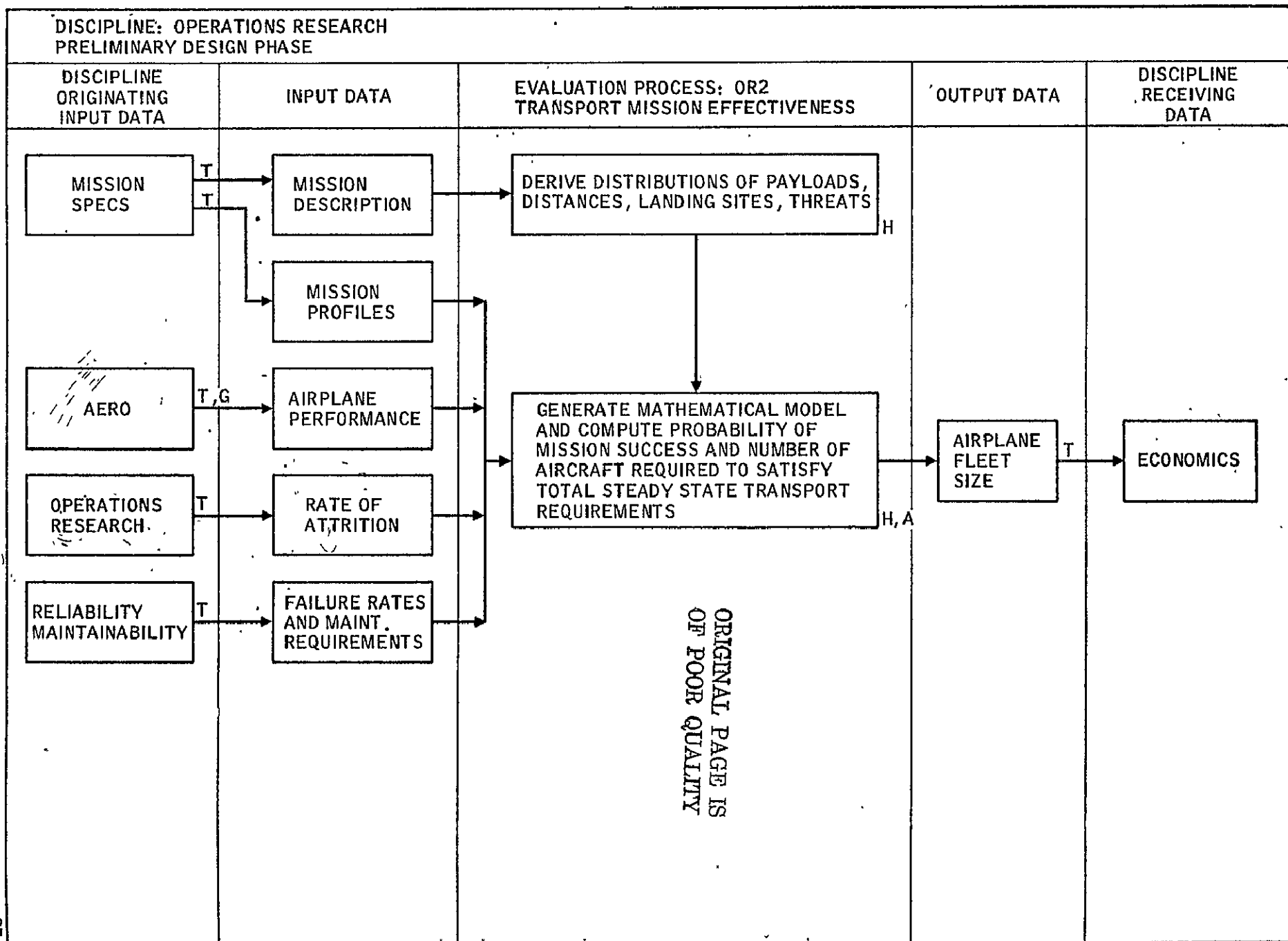


Figure 3-72. Transport Mission Effectiveness

DISCIPLINE: OPERATIONS RESEARCH
PRELIMINARY DESIGN PHASE

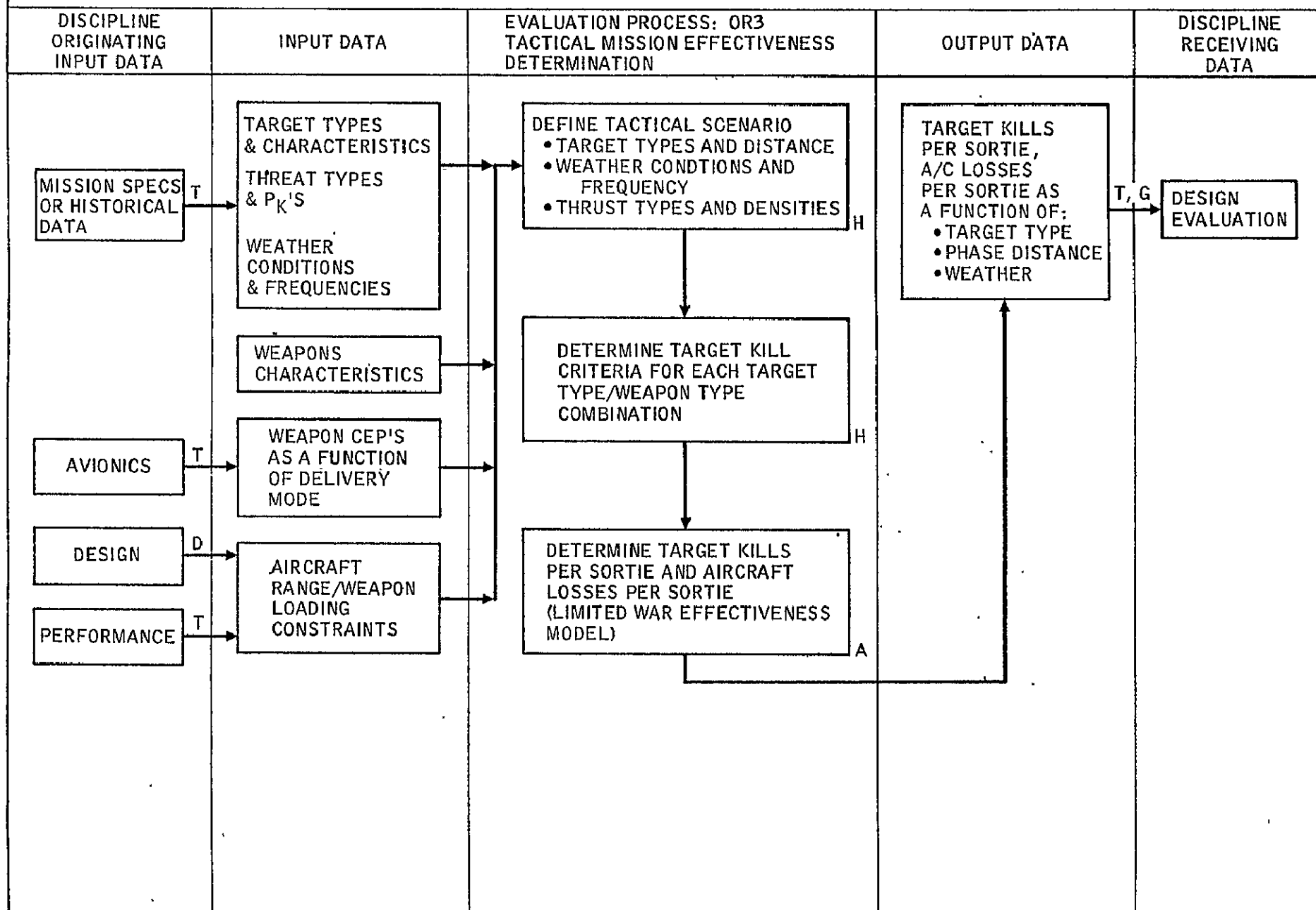


Figure 3-73. Tactical Mission Effectiveness Determination

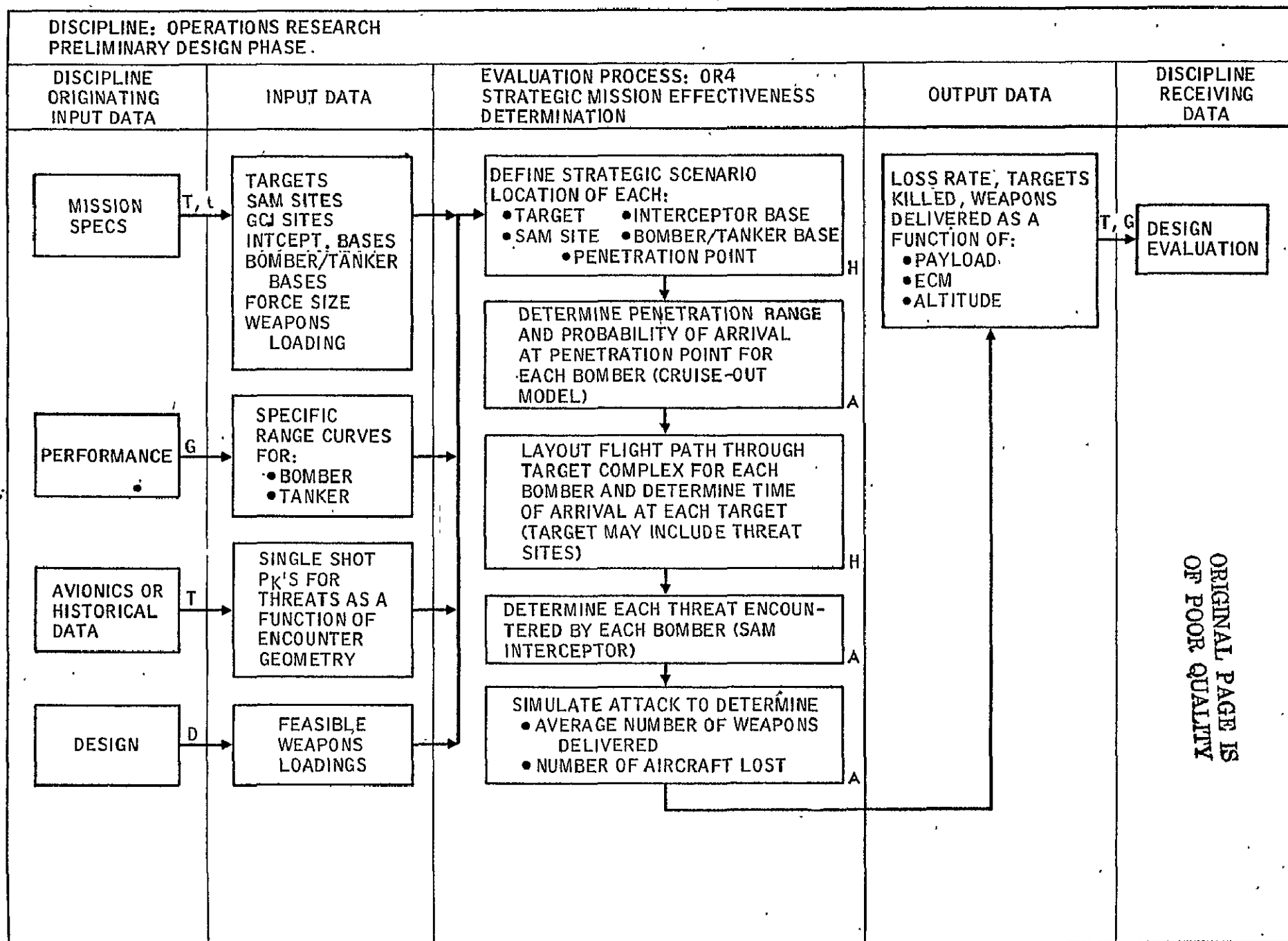
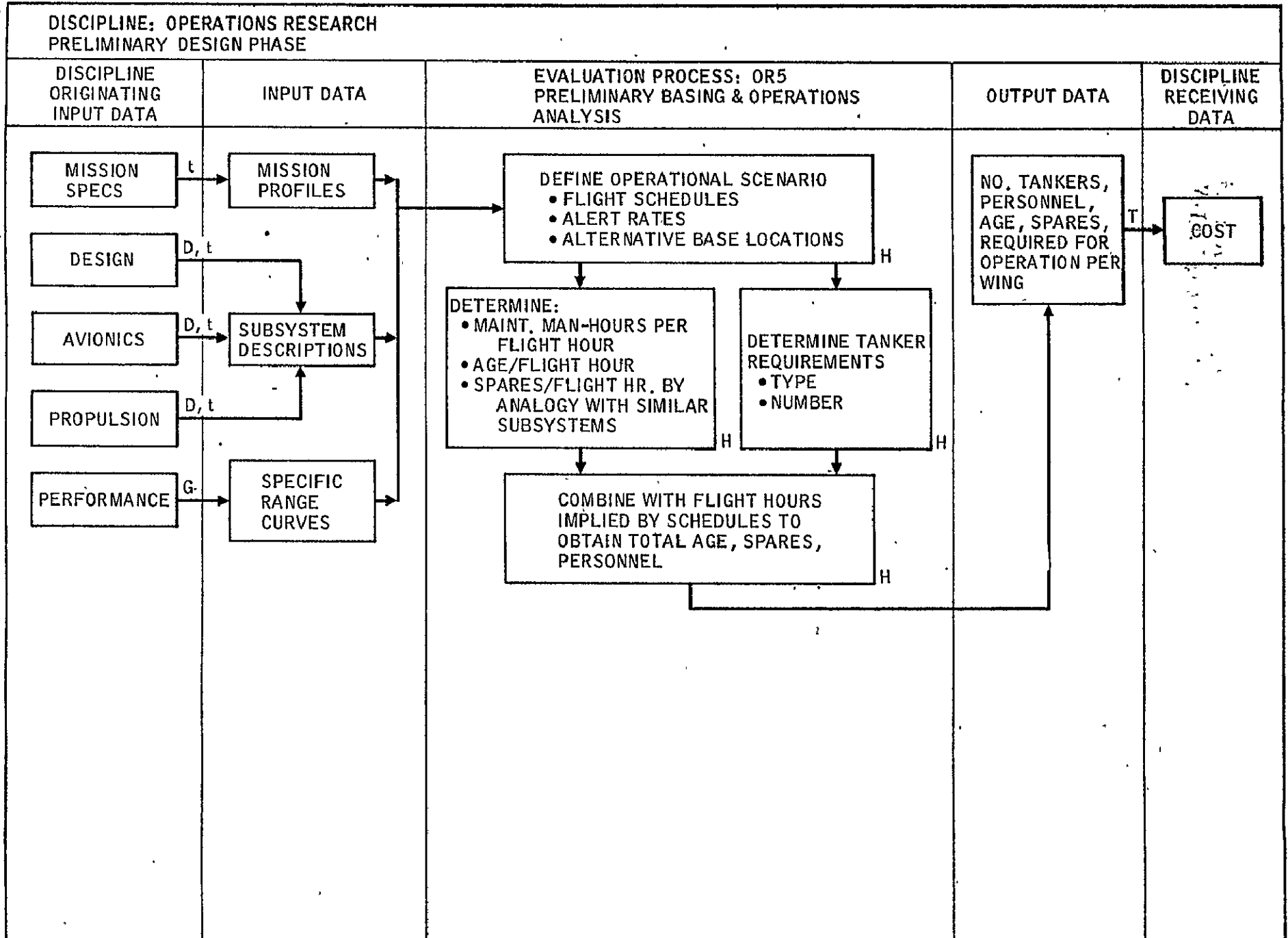


Figure 3-74. Strategic Mission Effectiveness Determination



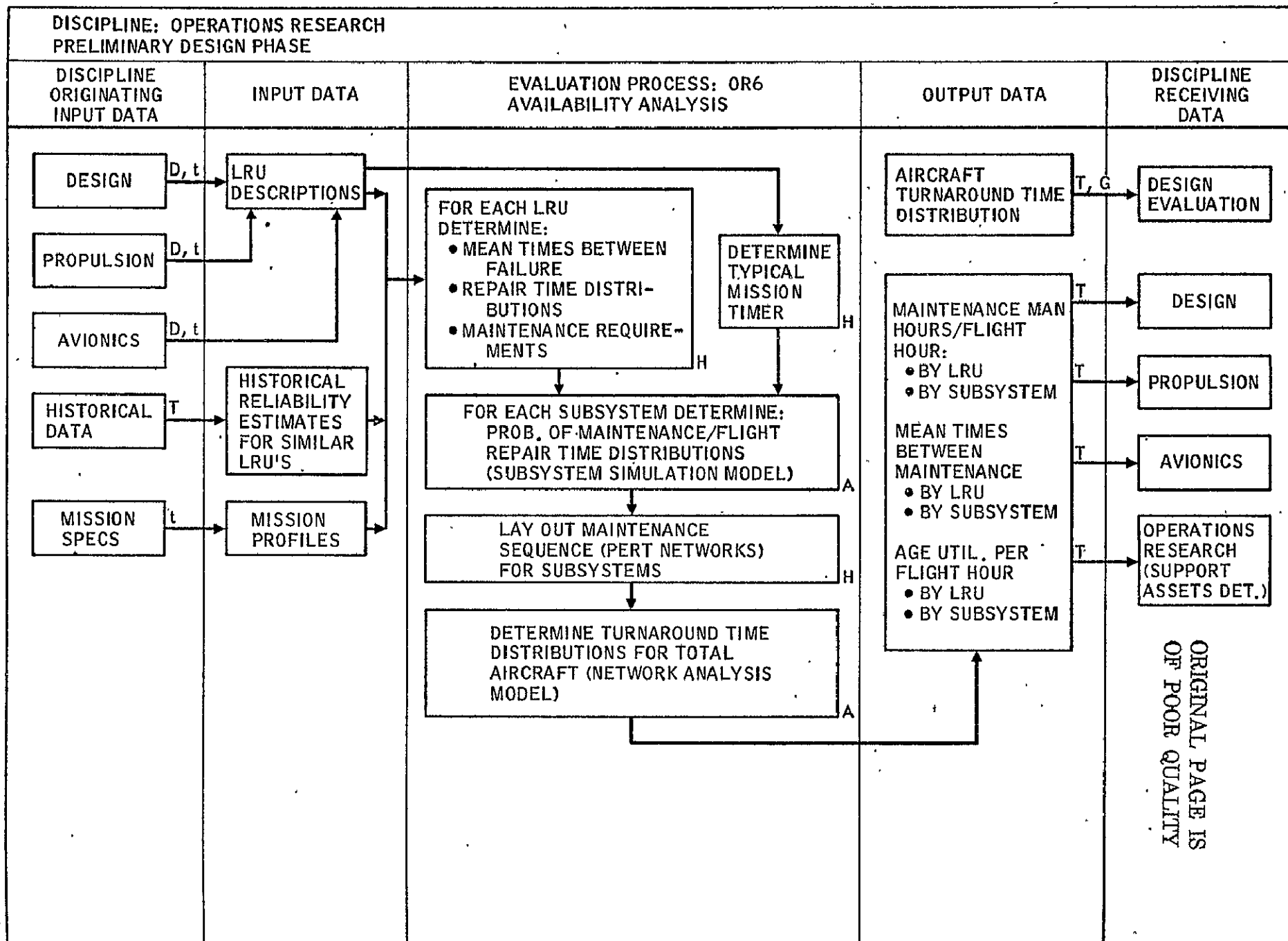
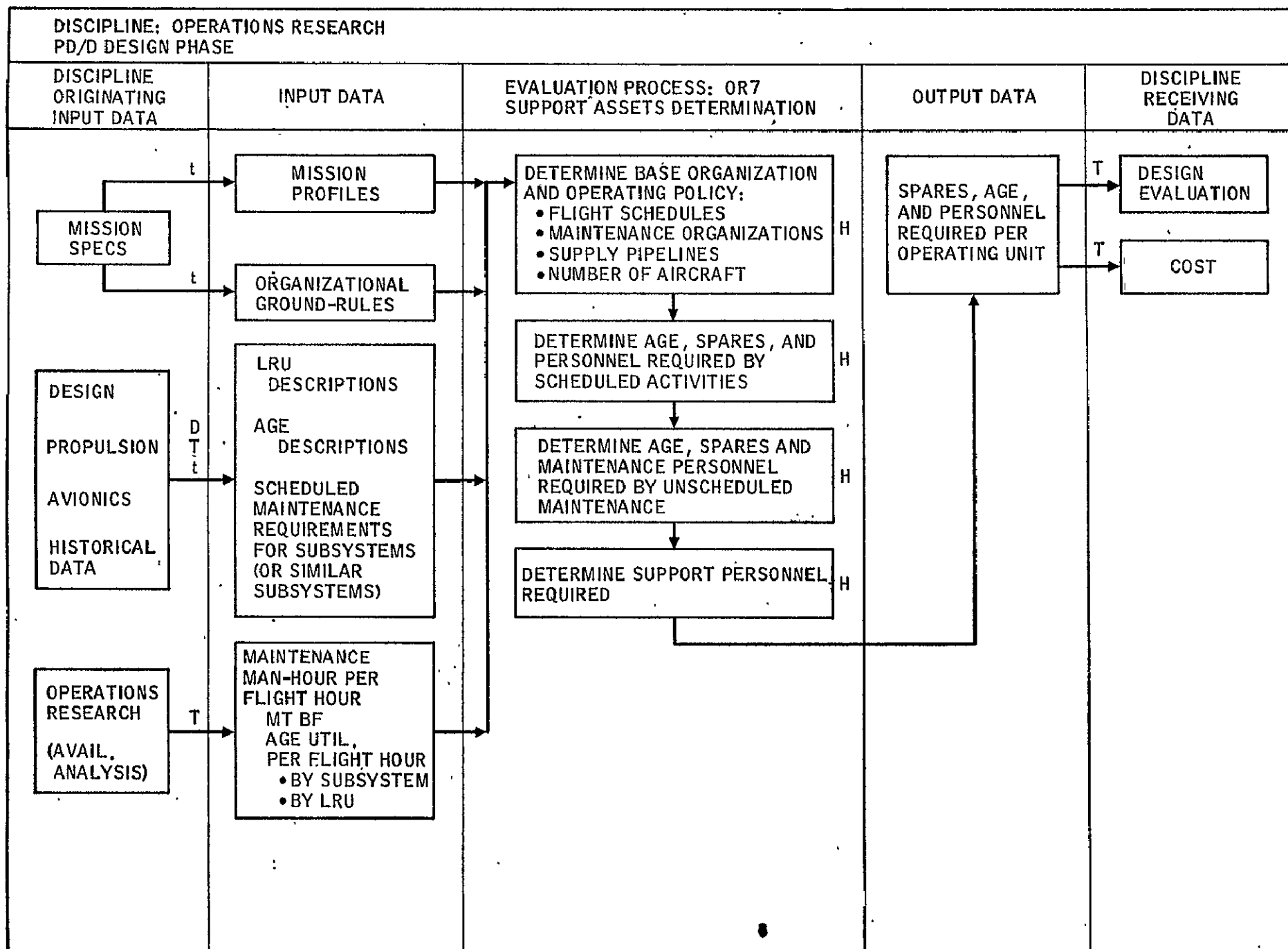


Figure 3-76. Availability Analysis



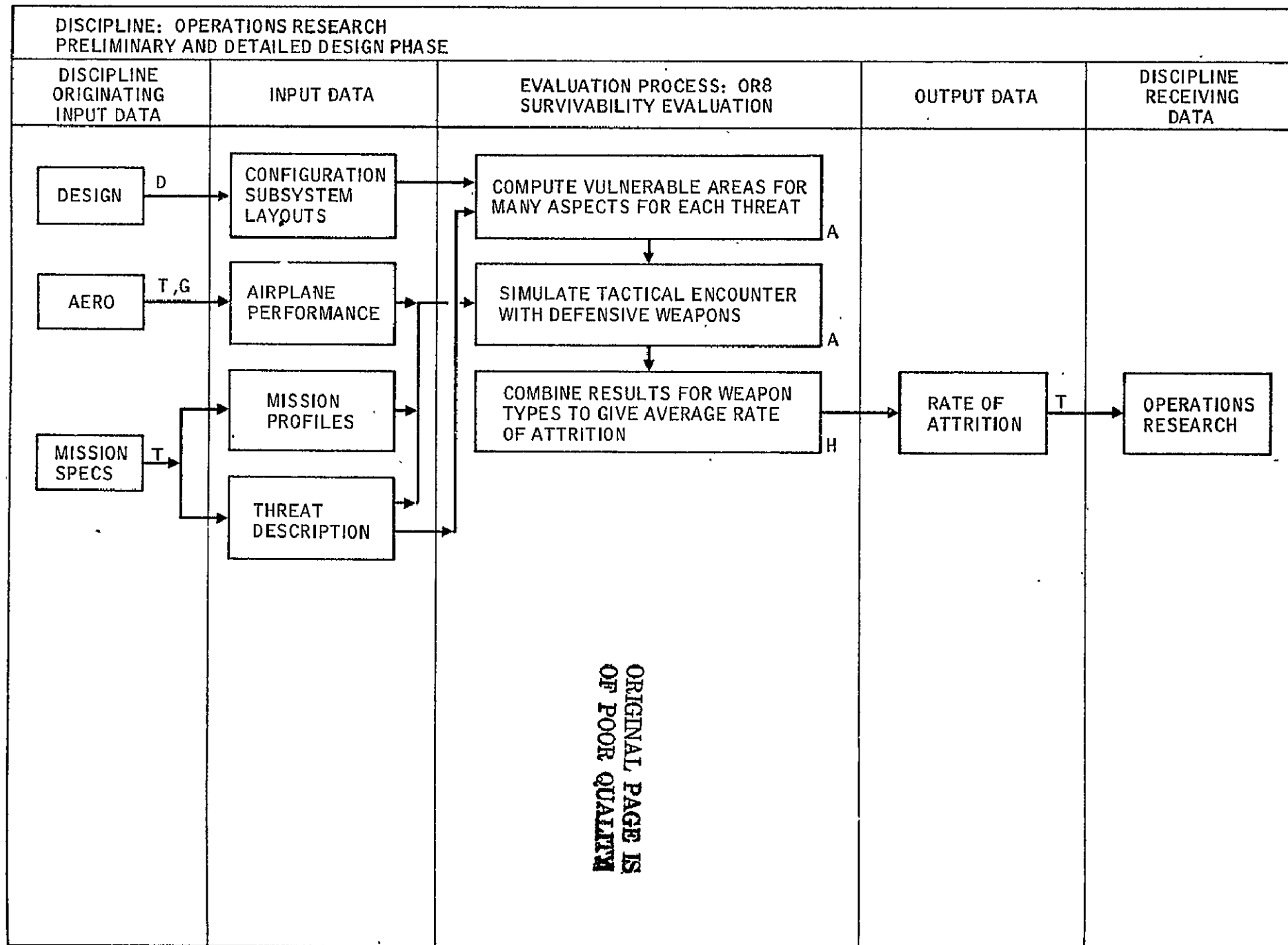
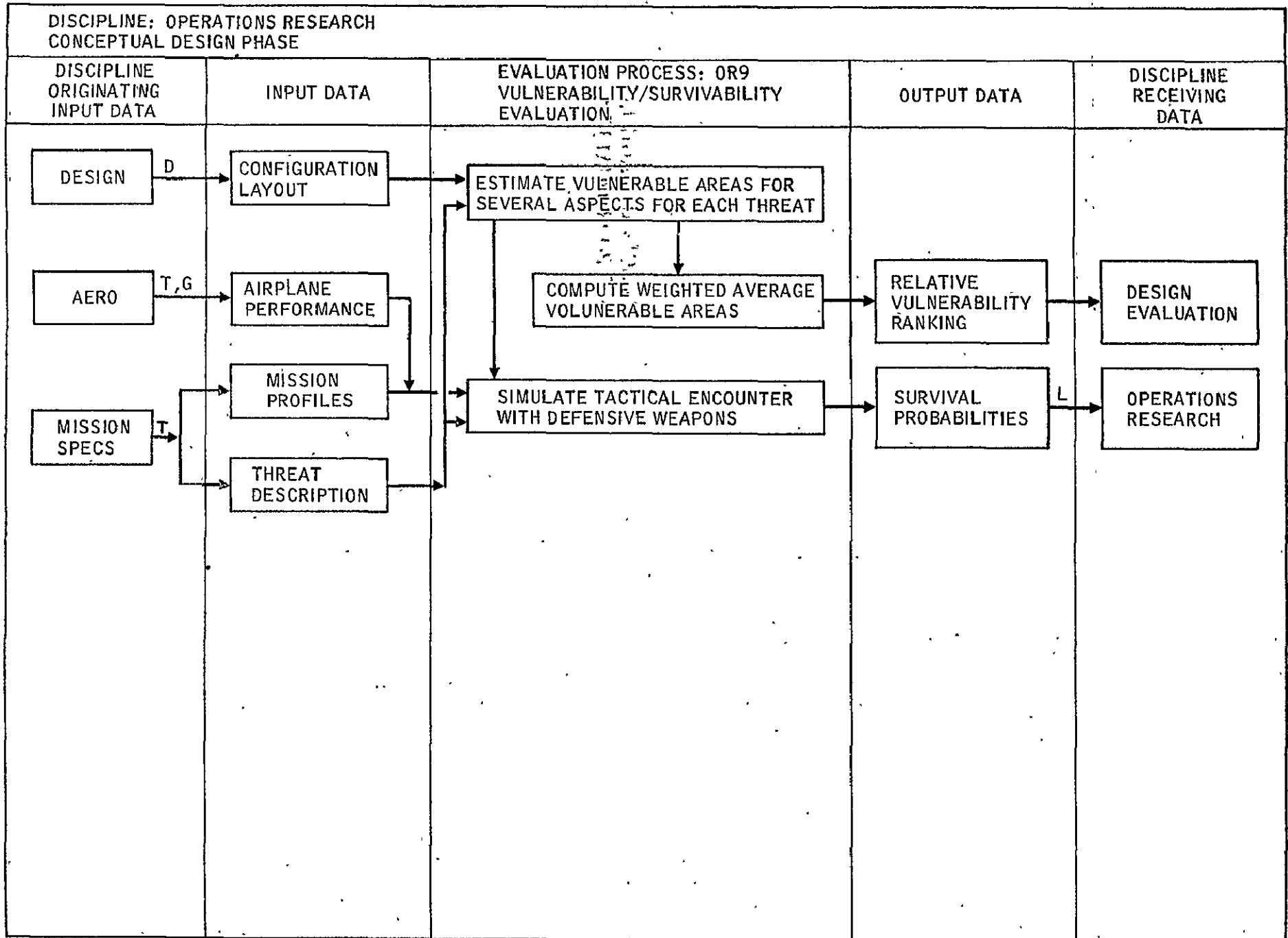


Figure 3-78. Survivability Evaluation



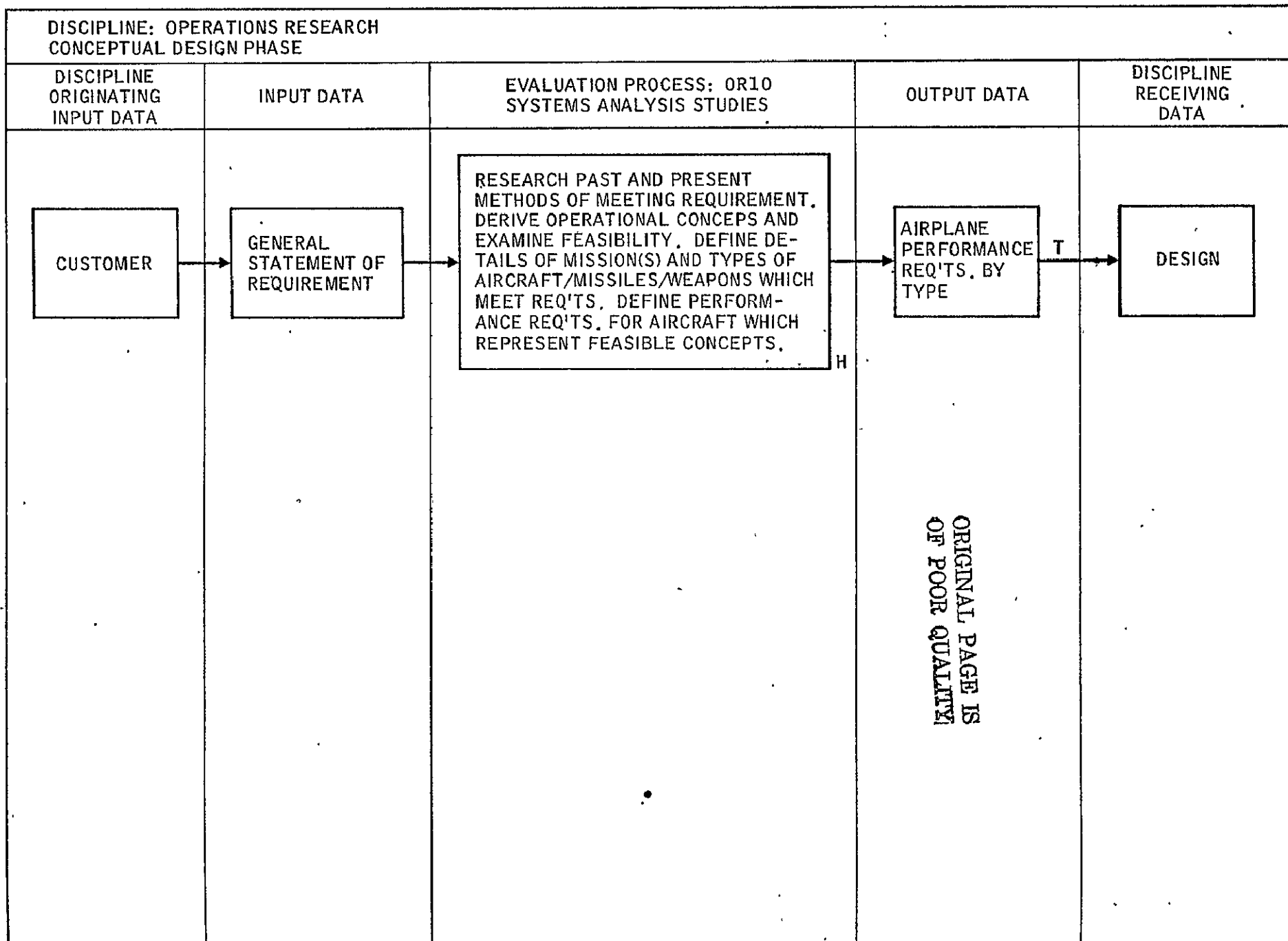
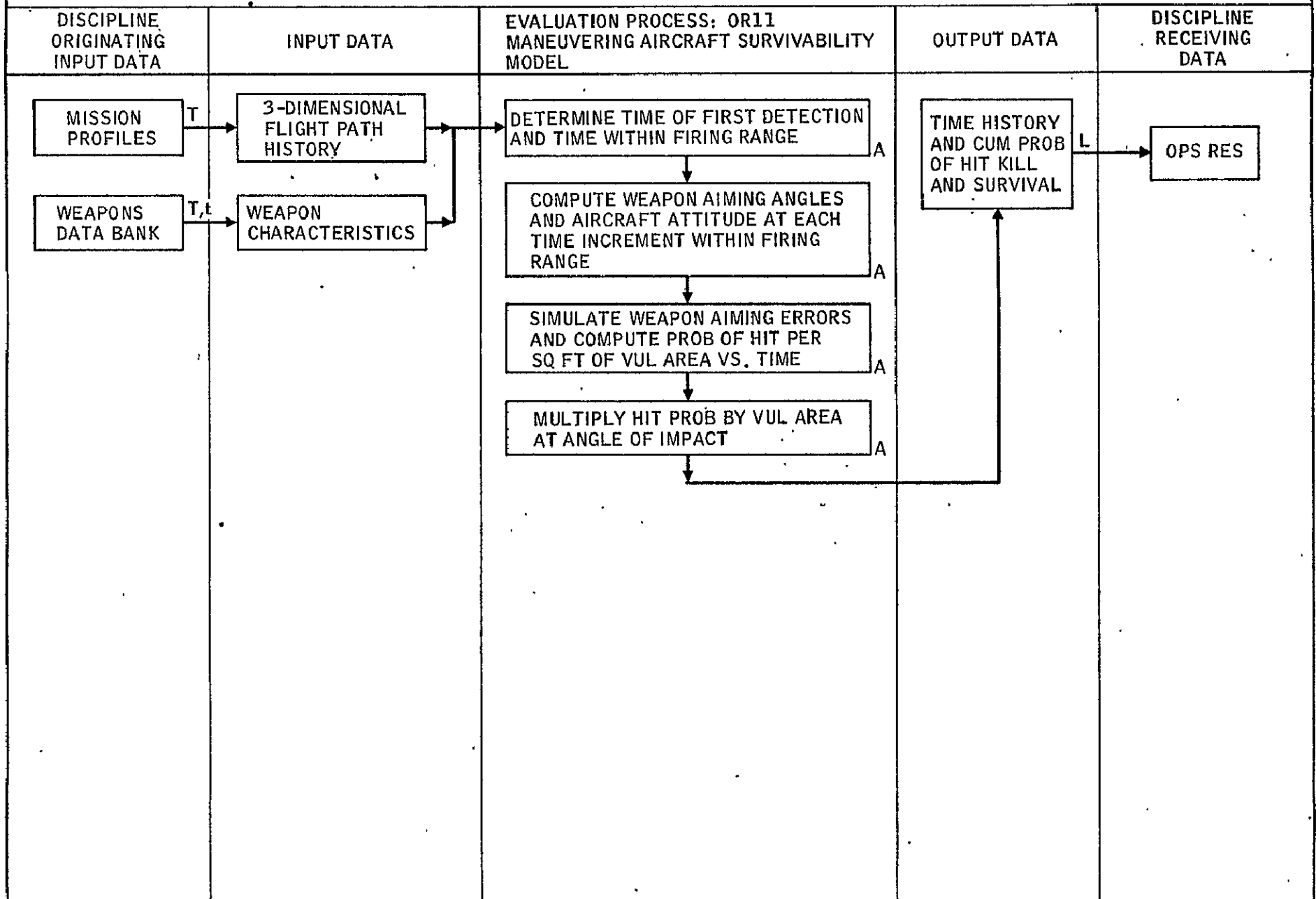


Figure 3-80. System Analysis Studies

DISCIPLINE: OPERATIONS RESEARCH
DETAILED DESIGN PHASE



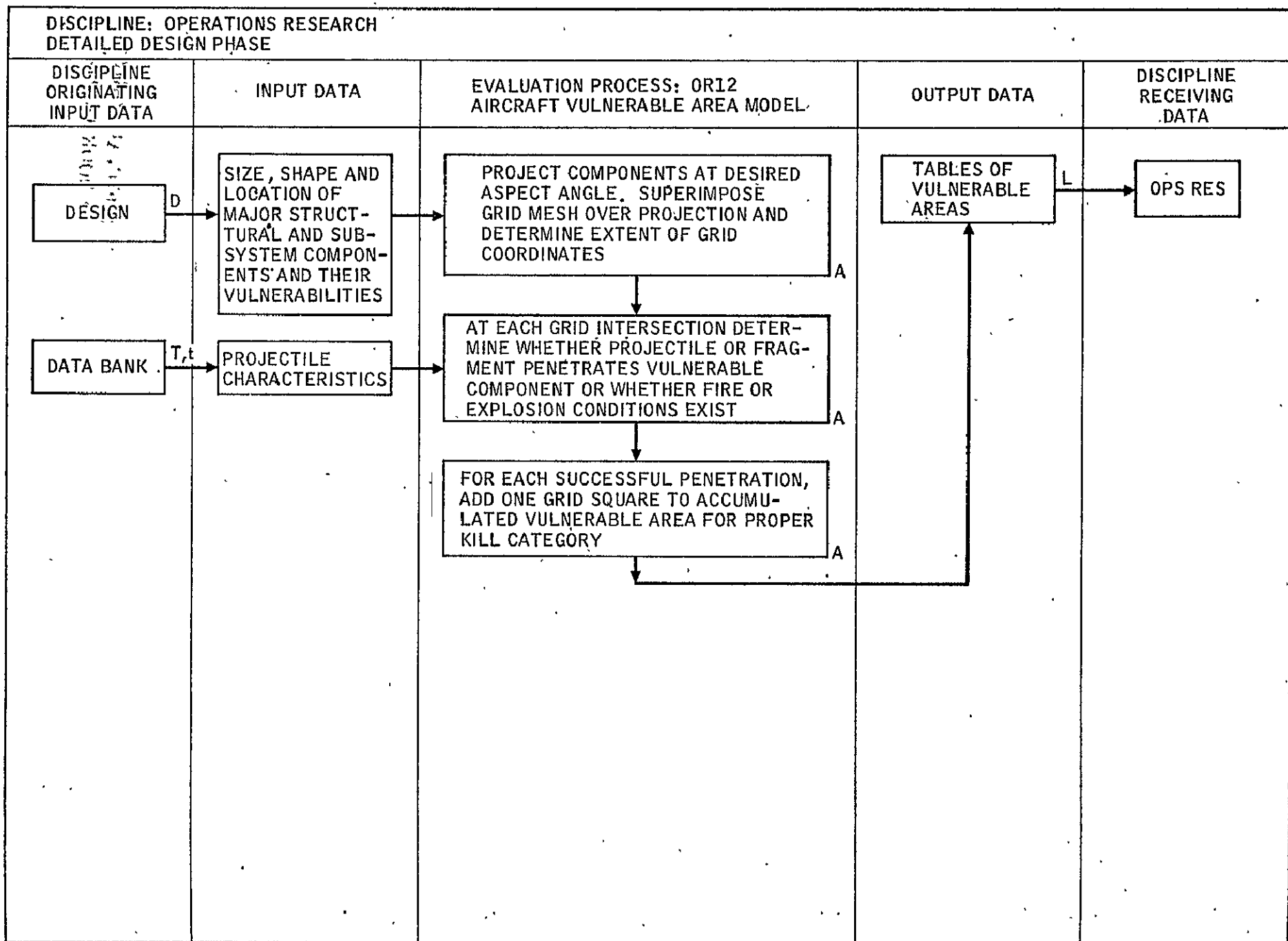
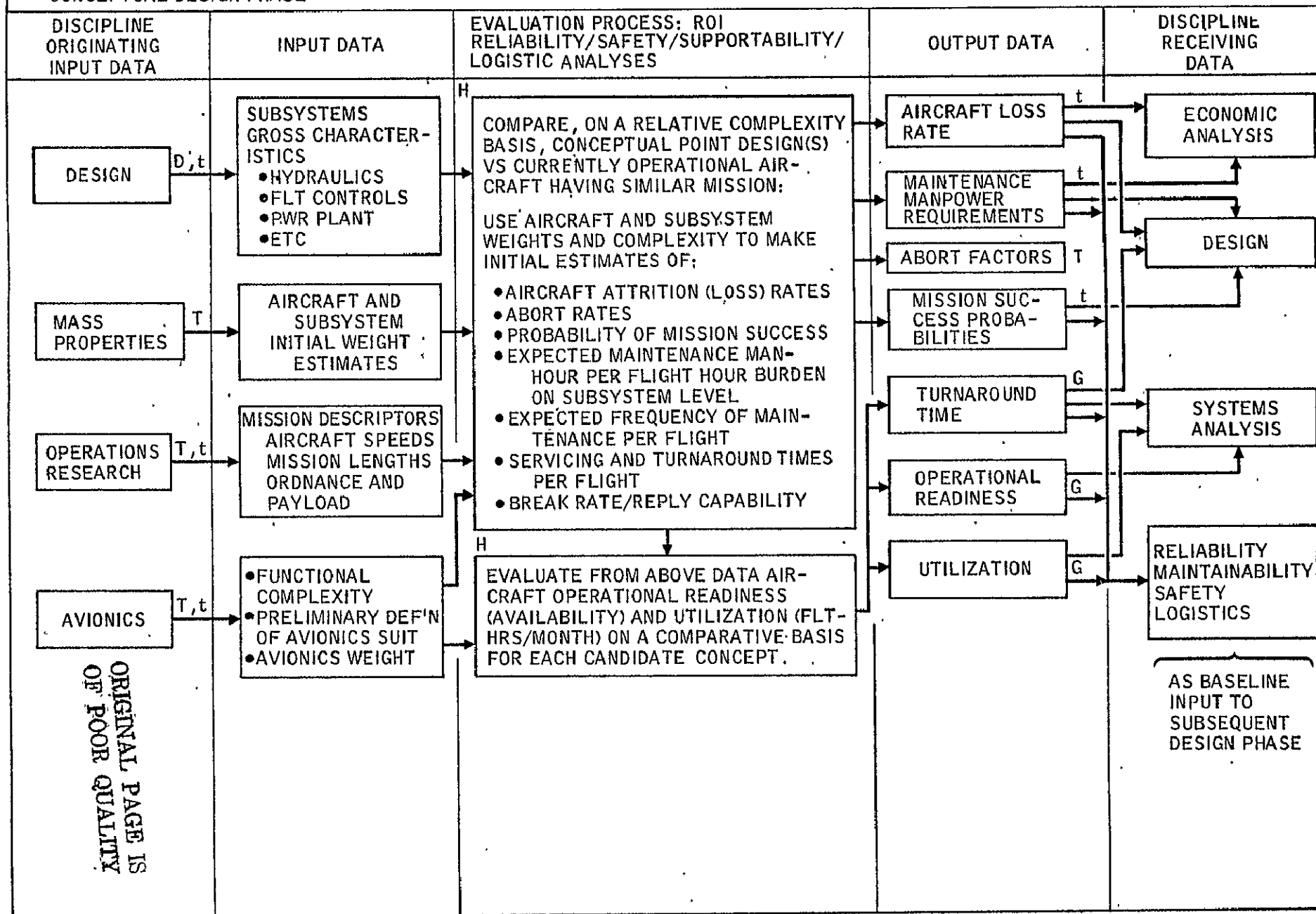


Figure 3-82. Aircraft Vulnerable Area Model

DISCIPLINE: RELIABILITY/SAFETY/SUPPORTABILITY/LOGISTICS
CONCEPTUAL DESIGN PHASE



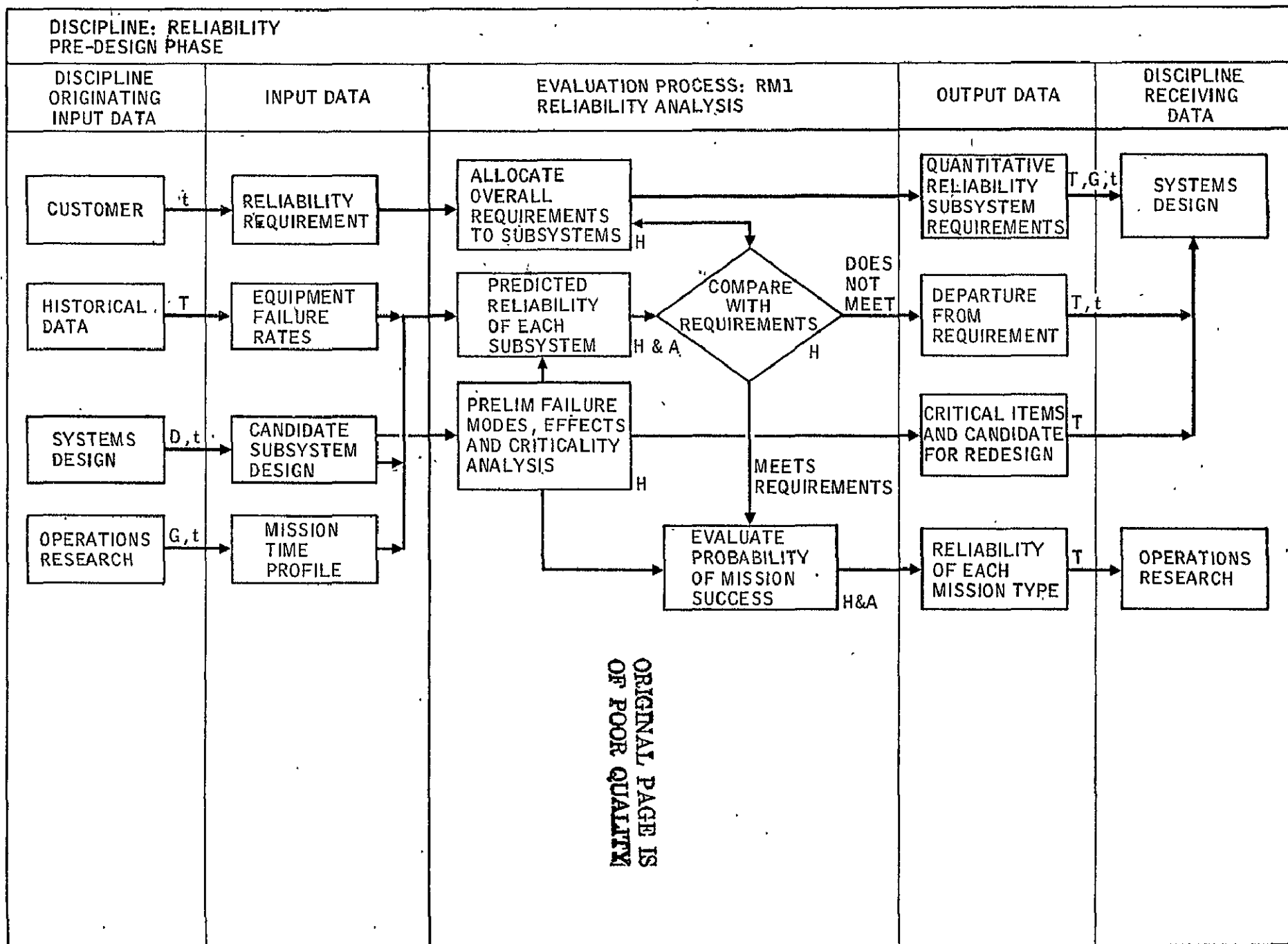
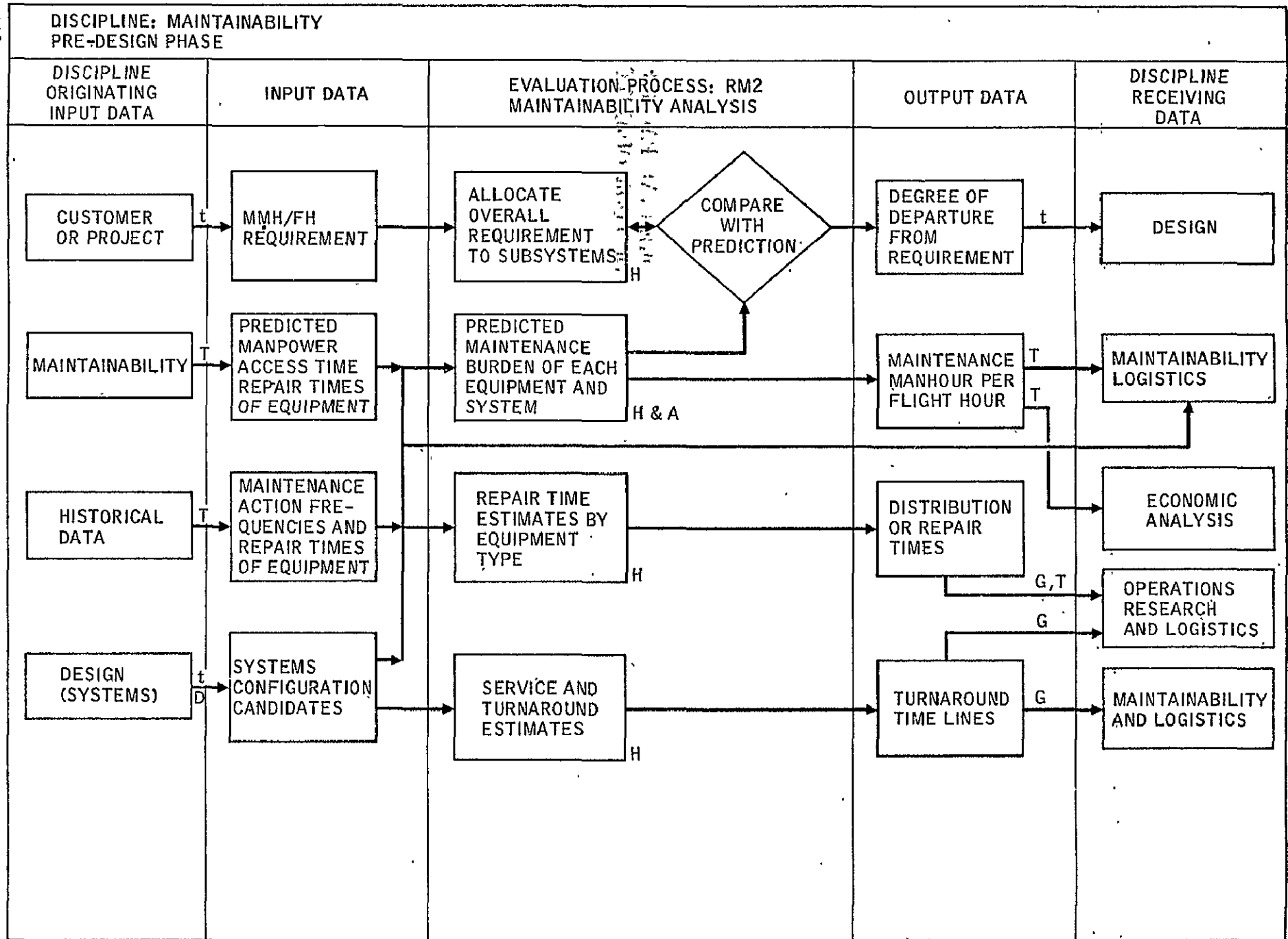


Figure 3-84. Reliability Analysis



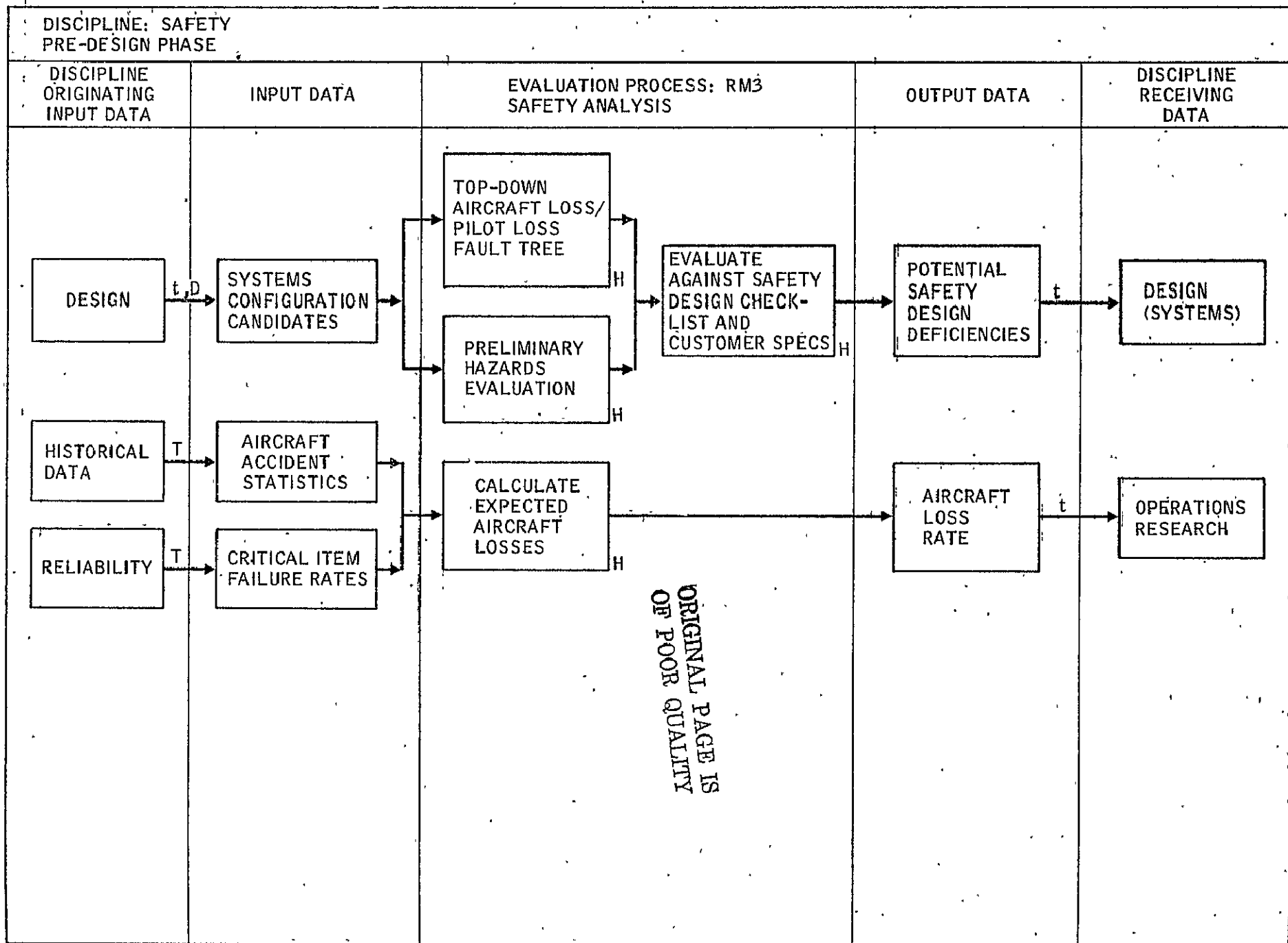


Figure 3-86. Safety Analysis

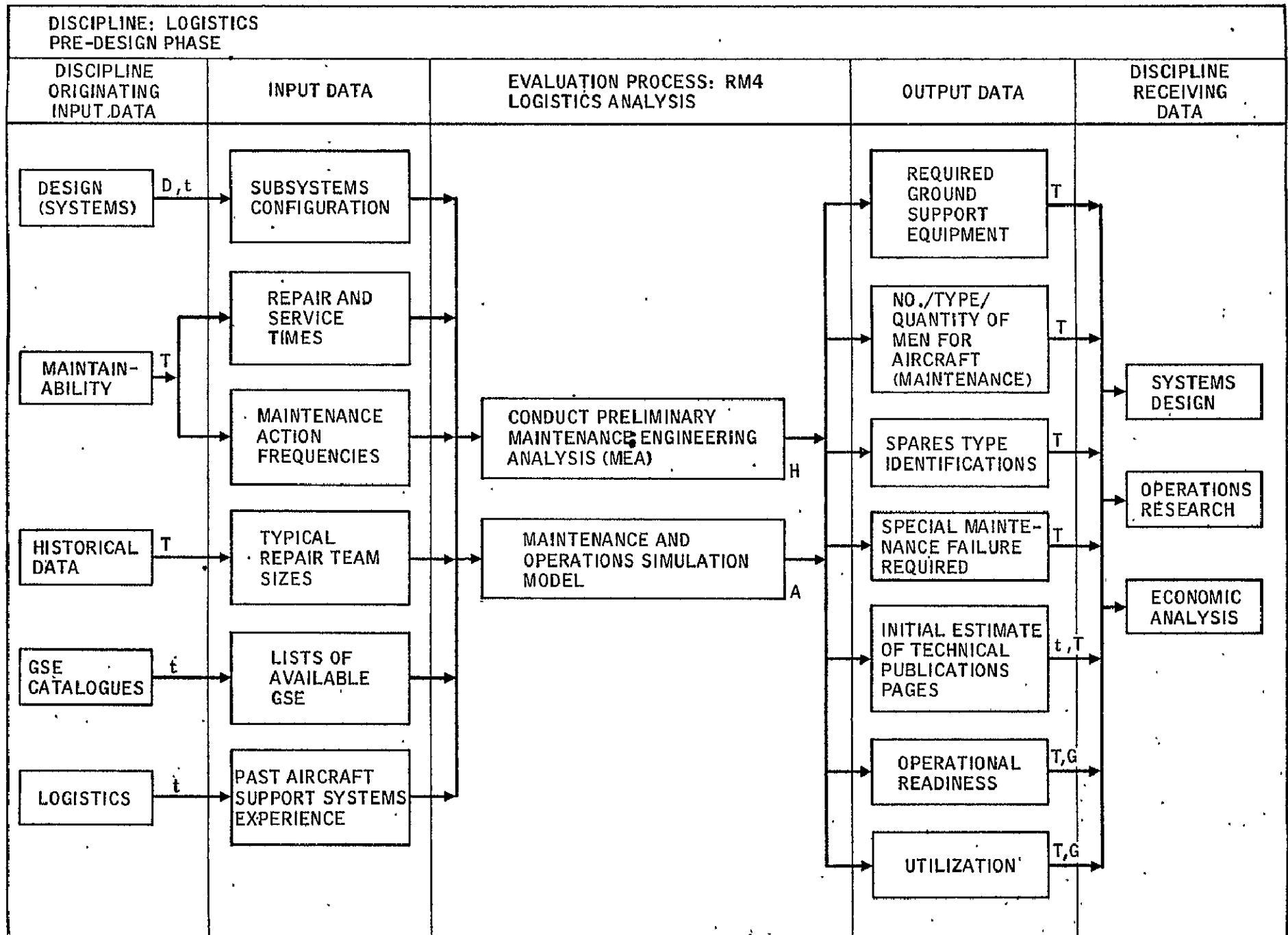


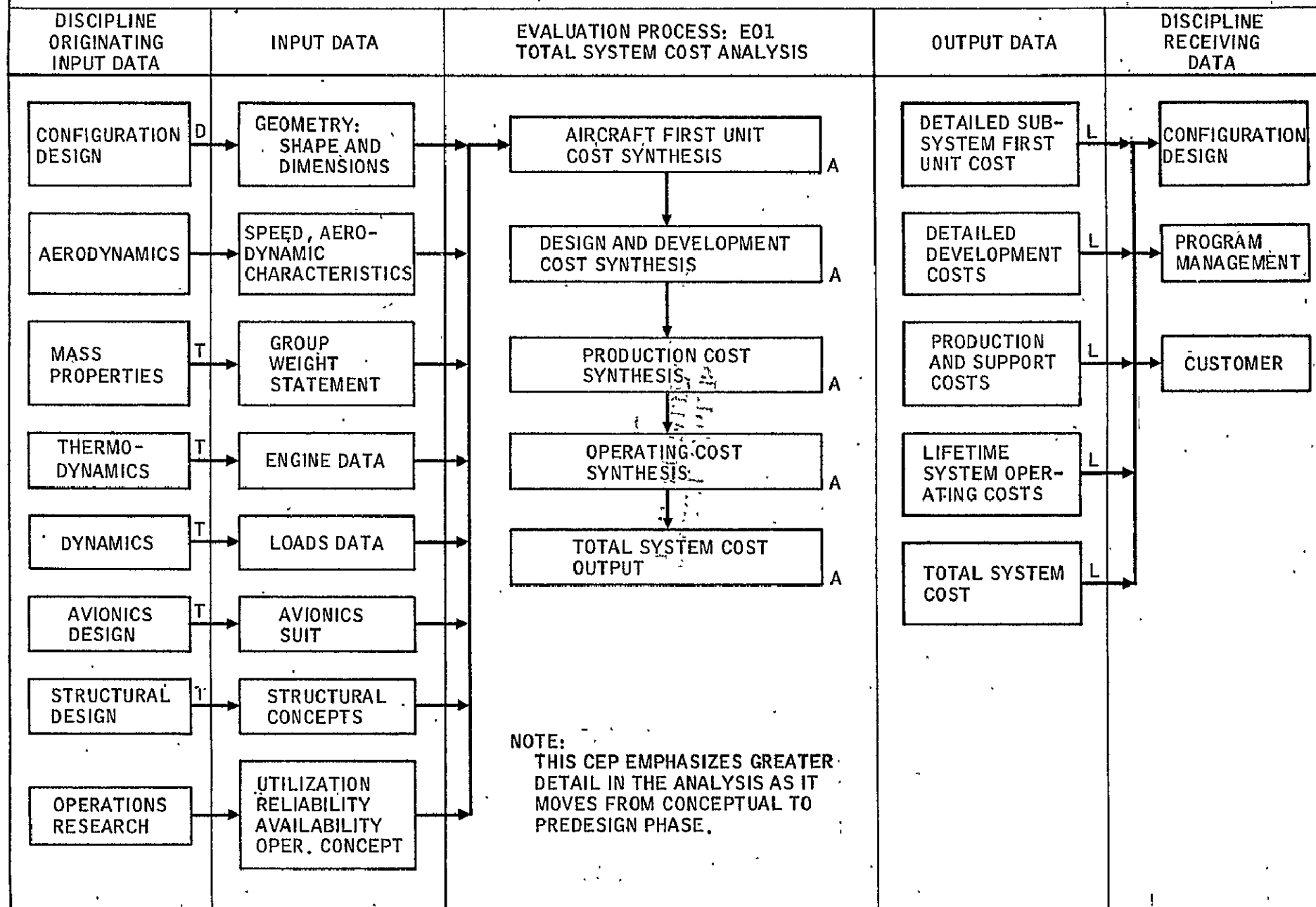
TABLE 3-9. ECONOMIC ANALYSIS CEP'S AND COMPUTER PROGRAMS

TASKS	CEP	Design Phase		
		C	PD	DD
Total System Cost Analysis	E01	x	x	
Cost Sensitivity and Design Trade Off Analysis	E02	x	x	x
COMPUTER PROGRAMS				
COSTC Total system parametric cost model		x	x	x
STRCOST Airframe structure cost analysis			x	x

TABLE 3-10. THEORETICAL FIRST-UNIT COST

AIRFRAME	
Basic Structure	Cooling System
Wing	Lubricating System
Body	Fuel System (Less Tanks)
Empennage	Fuel Tanks
Nacelle	Engine Controls
	Starting System
Subsystems	Primary & Final Assembly
Lighting Gear	Mission Equipment Installation
Surface Controls	Acceptance Operations
Auxiliary Power	
Instruments & Navigation	PROPULSION
Hydraulic & Pneumatic	Primary
Electrical	Secondary
Electronics	
Armor	AVIONICS
Furnishings & Equipment	New Design
Air Conditioning & Anti-Icing	Prior Prediction
Photographic	
Auxiliary Gear	
Engine Associated	
Air Induction	
Exhaust System	
	TOTAL FIRST UNIT COST

DISCIPLINE: ECONOMIC ANALYSIS
CONCEPTUAL AND PREDESIGN DESIGN PHASE



TYPE CONSTRUCTION
DETAILED WEIGHTS
ENGINE THRUST
NO. ENGINES
MAXIMUM SPEED

REFERENCE
WEIGHTS
EACH SUBSYSTEM

REFERENCE
COST/LB
EACH SUBSYSTEM

COST/LB
WEIGHT SCALING
EACH SUBSYSTEM

OTHER CHARACTERISTICS
BYPASS
OVERALL PRESSURE RATIO

DIRECT
ESTIMATES
(IF DESIRED)

COST PERCENTAGE FACTORS
ASSEMBLY
MISSION EQUIP INSTALL.
ACCEPTANCES

AIRFRAME STRUCTURE

WING

\$/LB

WT

\$/LB X WT

BODY

\$/LB

WT

\$/LB X WT

ENGINE

\$/LB

LIFT

THRUST

CRUISE

\$/LB X THRUST

THEORETICAL FIRST-UNIT COST
AIRFRAME
PROPULSION
AVIONICS

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Figure 3-89. First-Unit Cost Model Functions

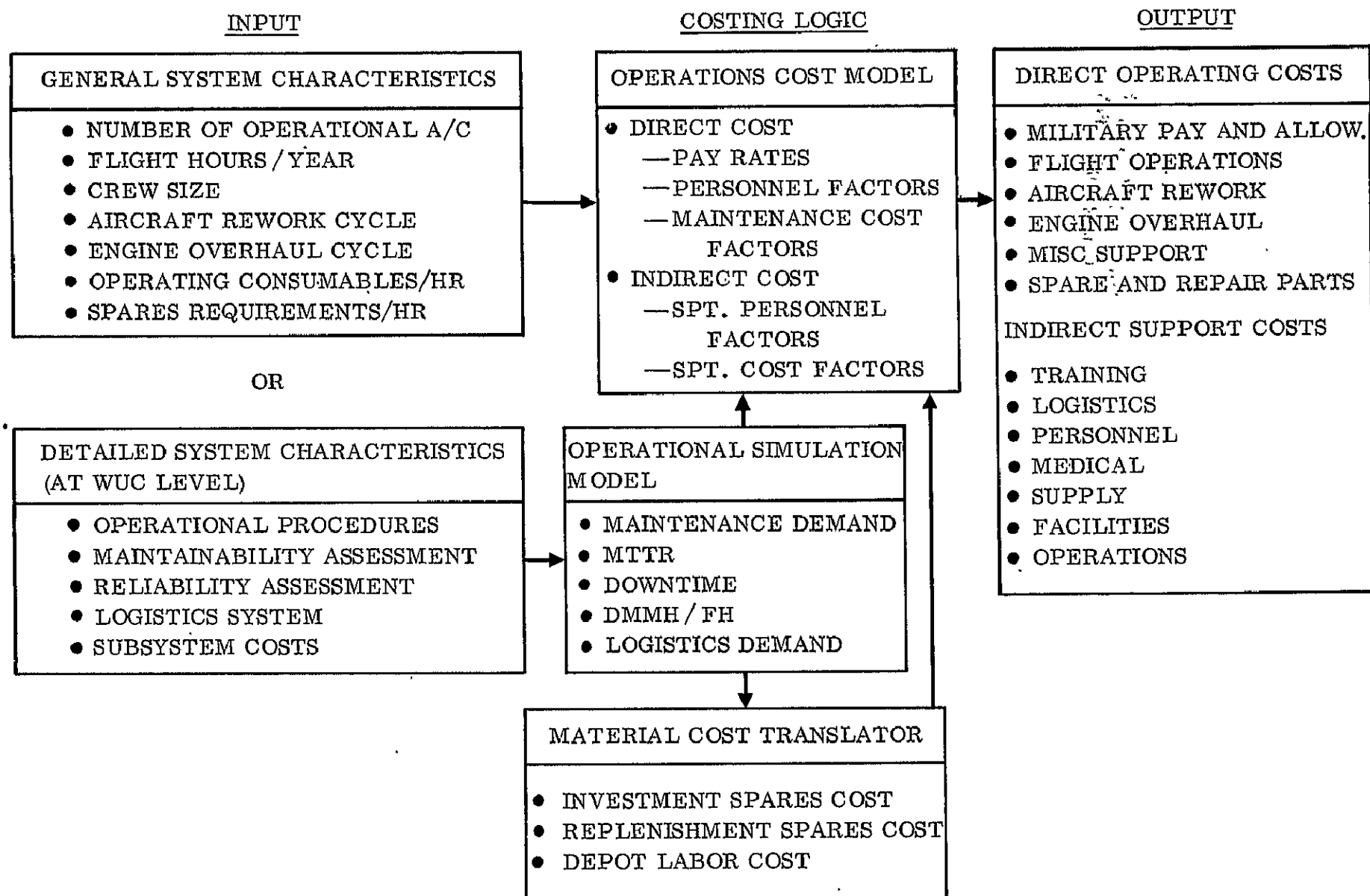


Figure 3-93. Operating Cost Estimating Methodology

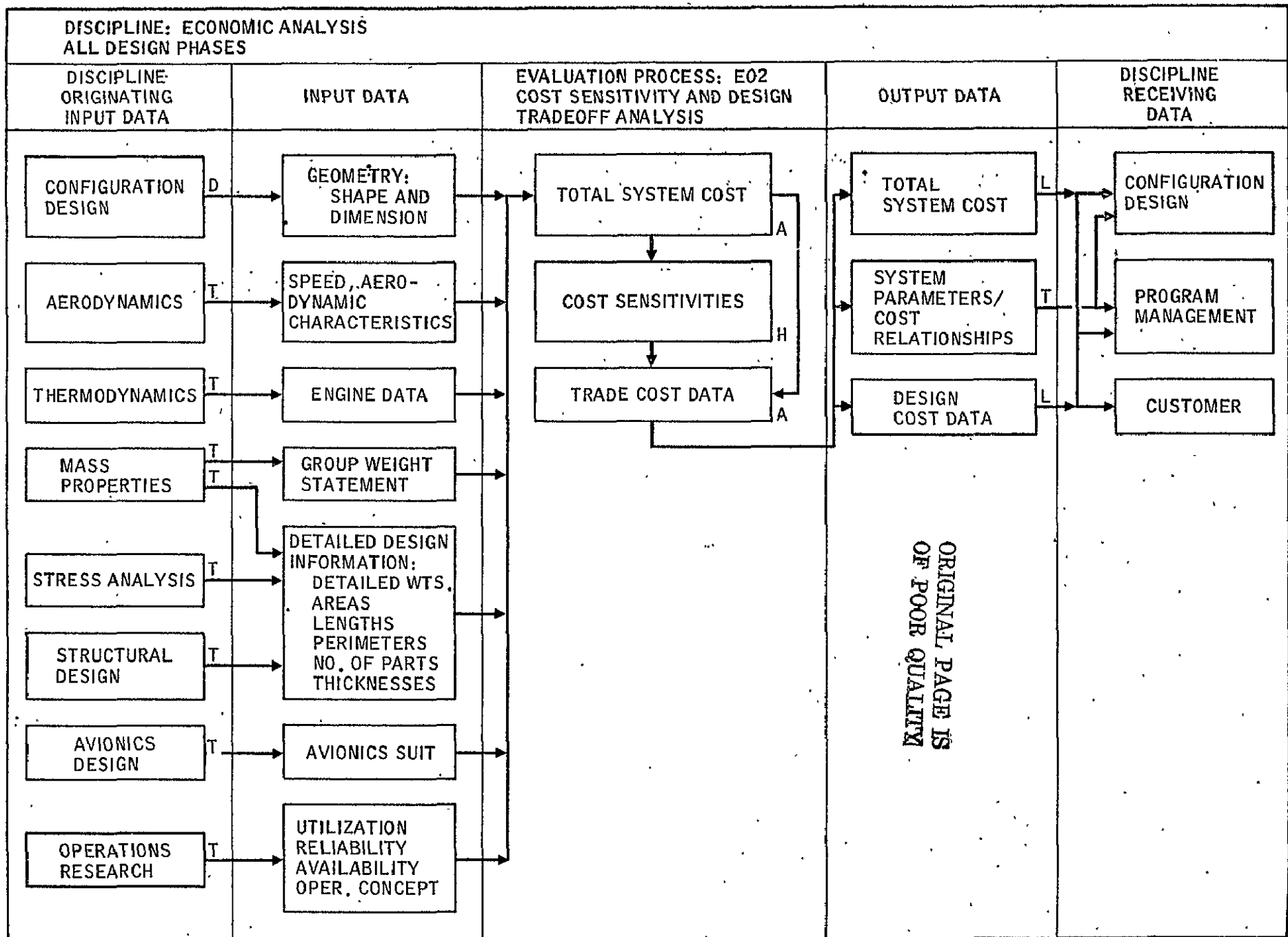


Figure 3-94. Cost Sensitivity and Design Tradeoff Analysis

TABLE 3-12. STRUCTURAL LOADS CEP'S AND COMPUTER PROGRAMS

TASKS	CEP	Design Phase		
		C	PD	DD
Establish Preliminary Structural Design Criteria	SL1	x		
Design Critique	SL2	x		
Formulate Design Criteria	SL3		x	x
Determine Preliminary Structural Layout Loads	SL4		x	
Perform Symmetric Maneuver Load Trend Survey	SL5		x	
Determine Landing and Ground Handling Design Loads	SL6		x	
Calculate Wing Panel Point Loads Distributions	SL7		x	x
Determine Fatigue Loads Spectra	SL8		x	
Perform Fatigue Evaluation	SL9		x	
Perform Gust Loads Analysis	SL10		x	
Support Loads Model Wind Tunnel Test Program	SL11		x	x
Airplane Rigid Body Initial Dynamic Maneuvers Response Parameters Envelope	SL12		x	
<u>COMPUTER PROGRAMS</u>				
RL1 Balanced Symmetric Maneuver Load Trends			x	x
RL9 MIL-A-8861 Discrete Gust Analysis			x	x
BO5 Fatigue Damage Due to Maneuver and Continuous Turbulence			x	
UB1 Landing Gear Design Loads (MIL-A-8862)			x	x
TC4 Wing and Tail Distributed Loads and Panel Point Loads			x	x

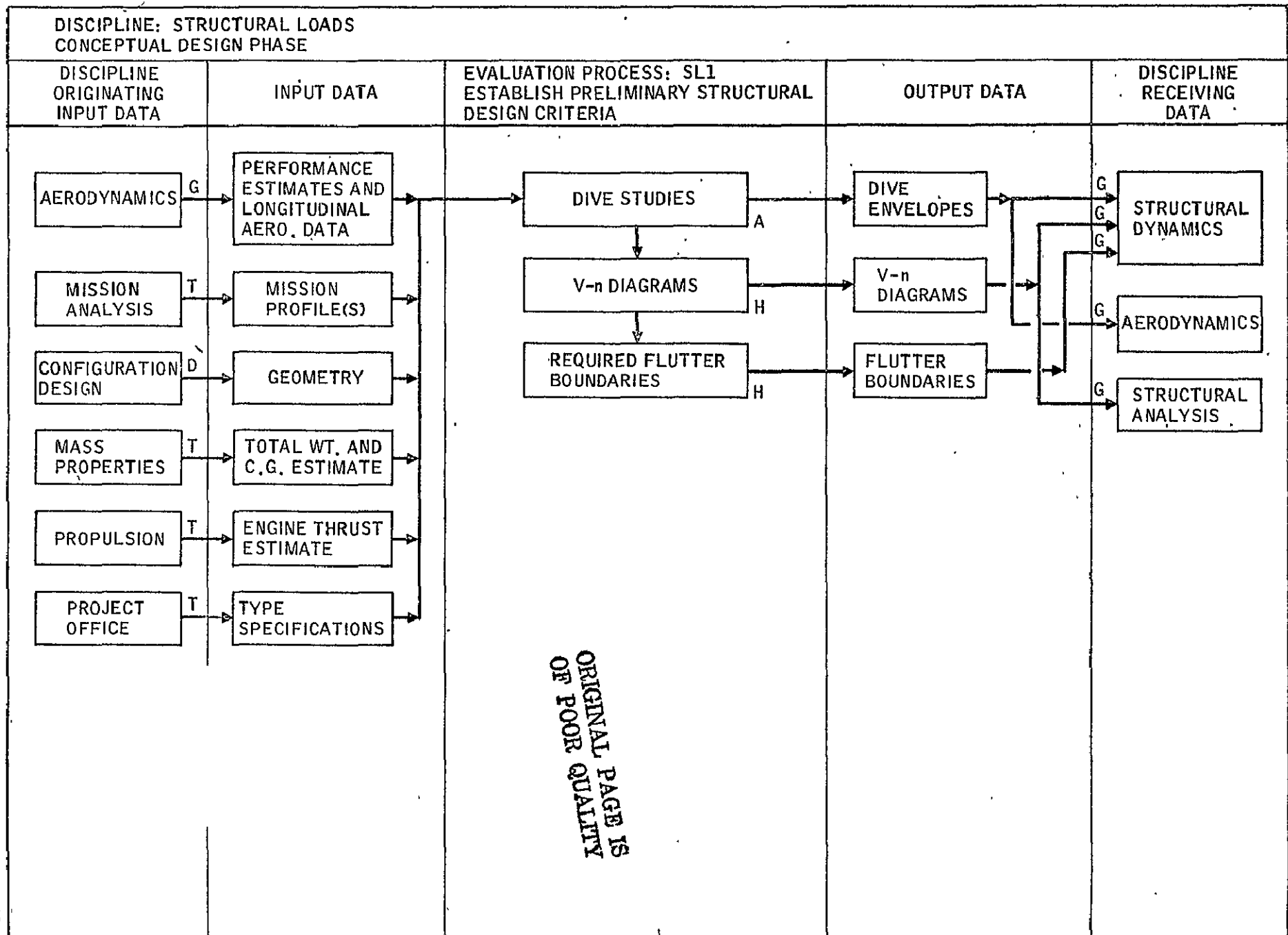
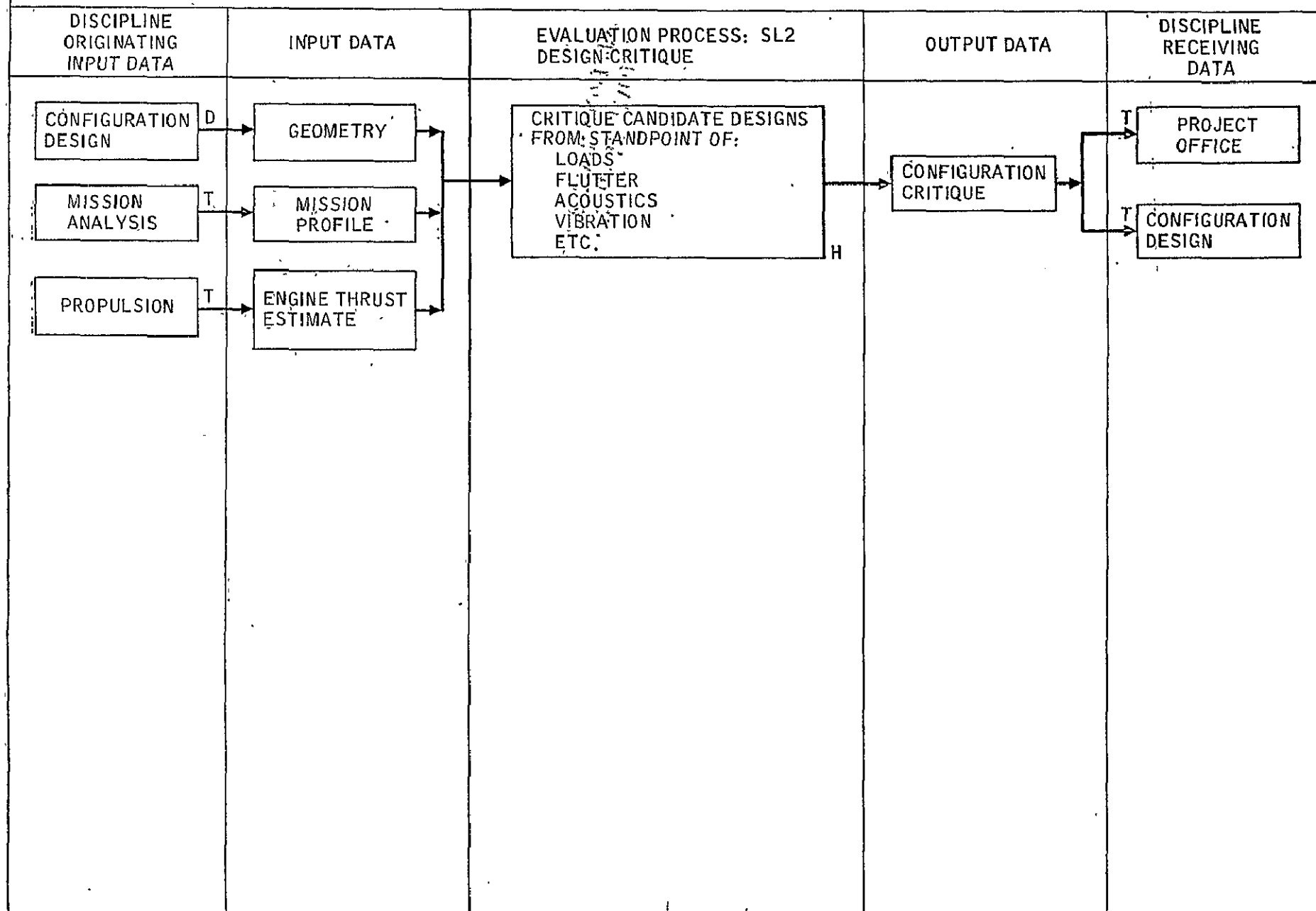


Figure 3-95. Preliminary Structural Design Criteria

DISCIPLINE: STRUCTURAL LOADS
CONCEPTUAL DESIGN PHASE



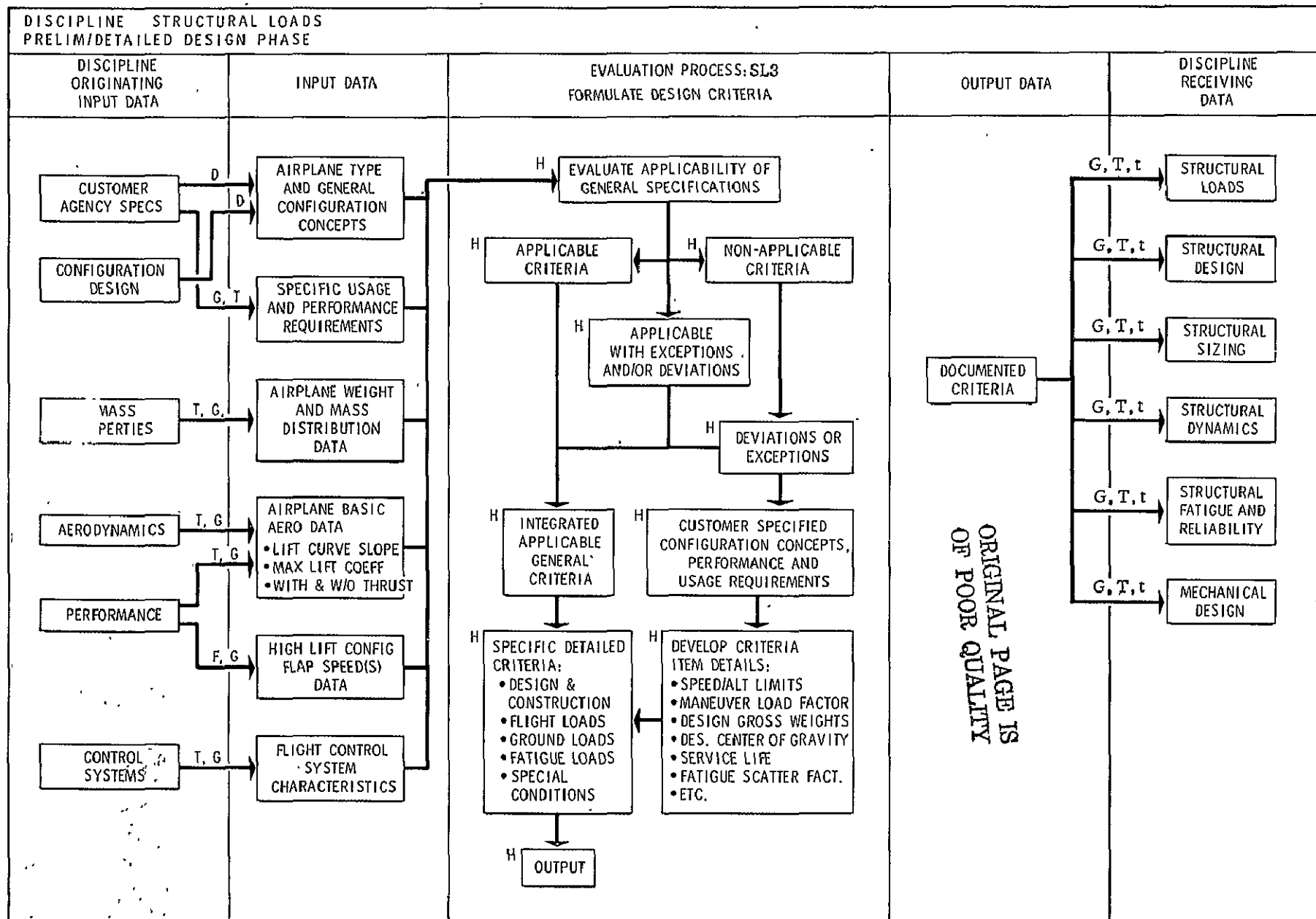


Figure 3-97. Formulate Design Criteria

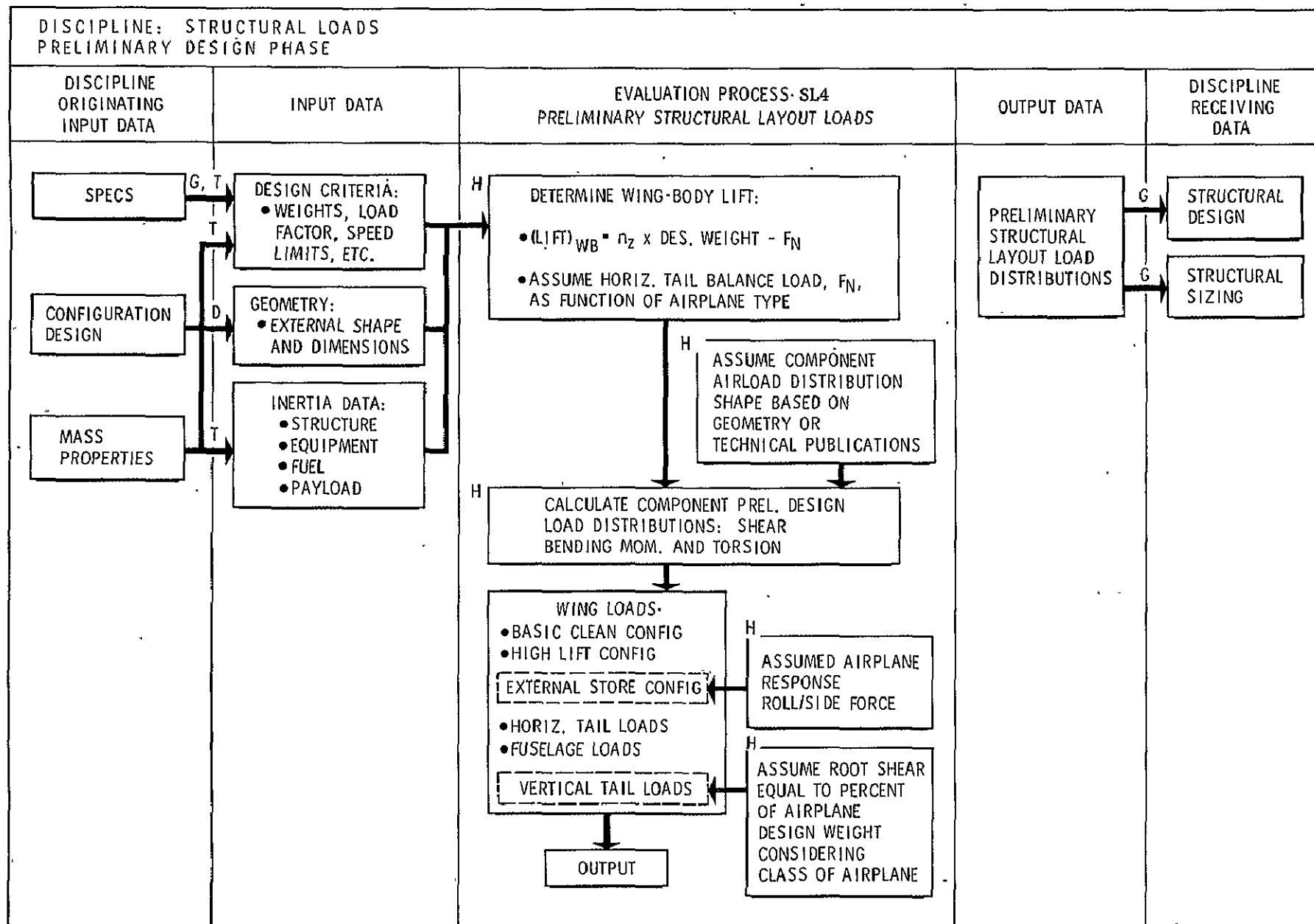


Figure 3-98. Preliminary Structural Layout Loads

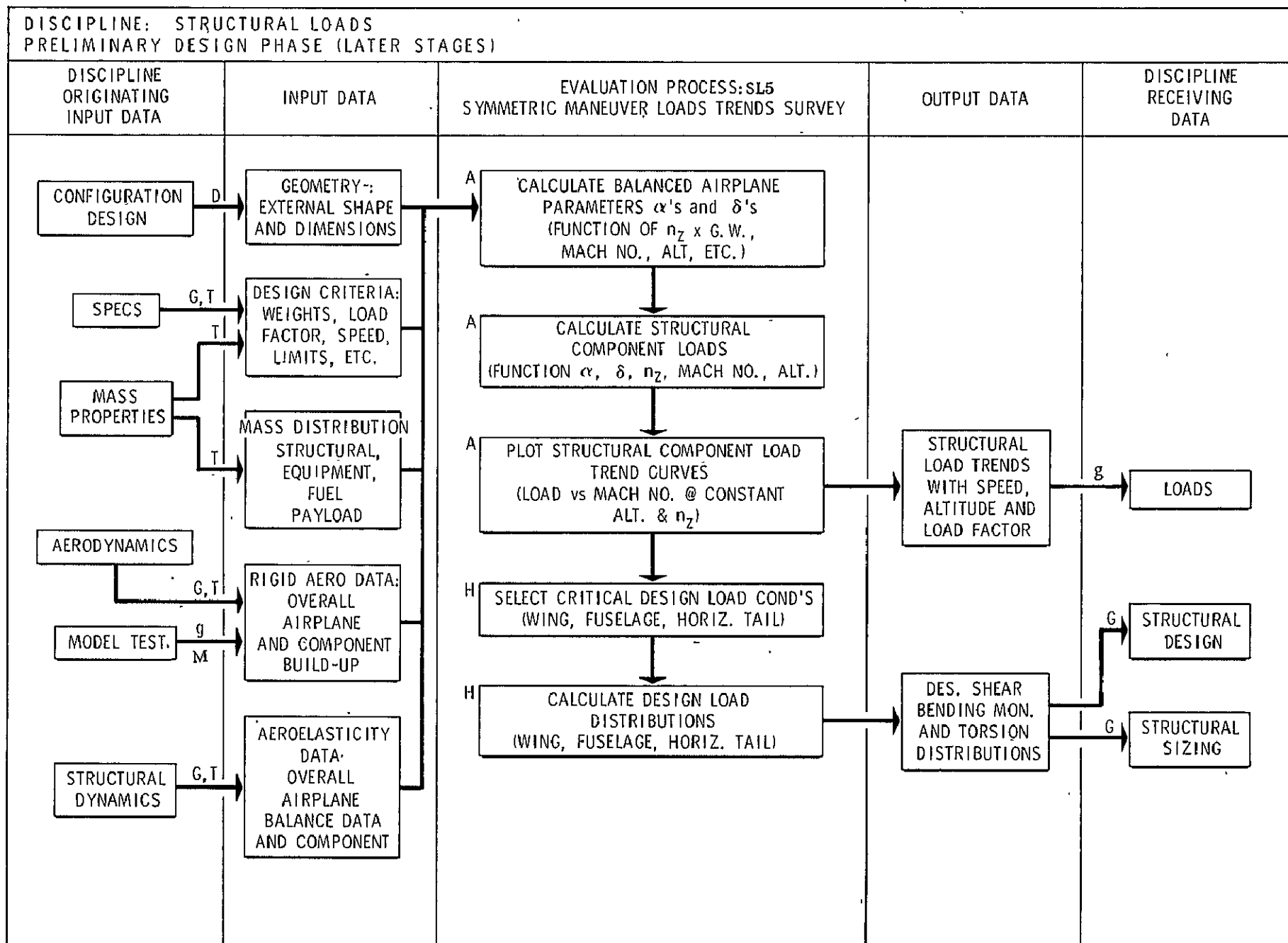


Figure 3-99. Symmetric Maneuver Loads Trend Survey

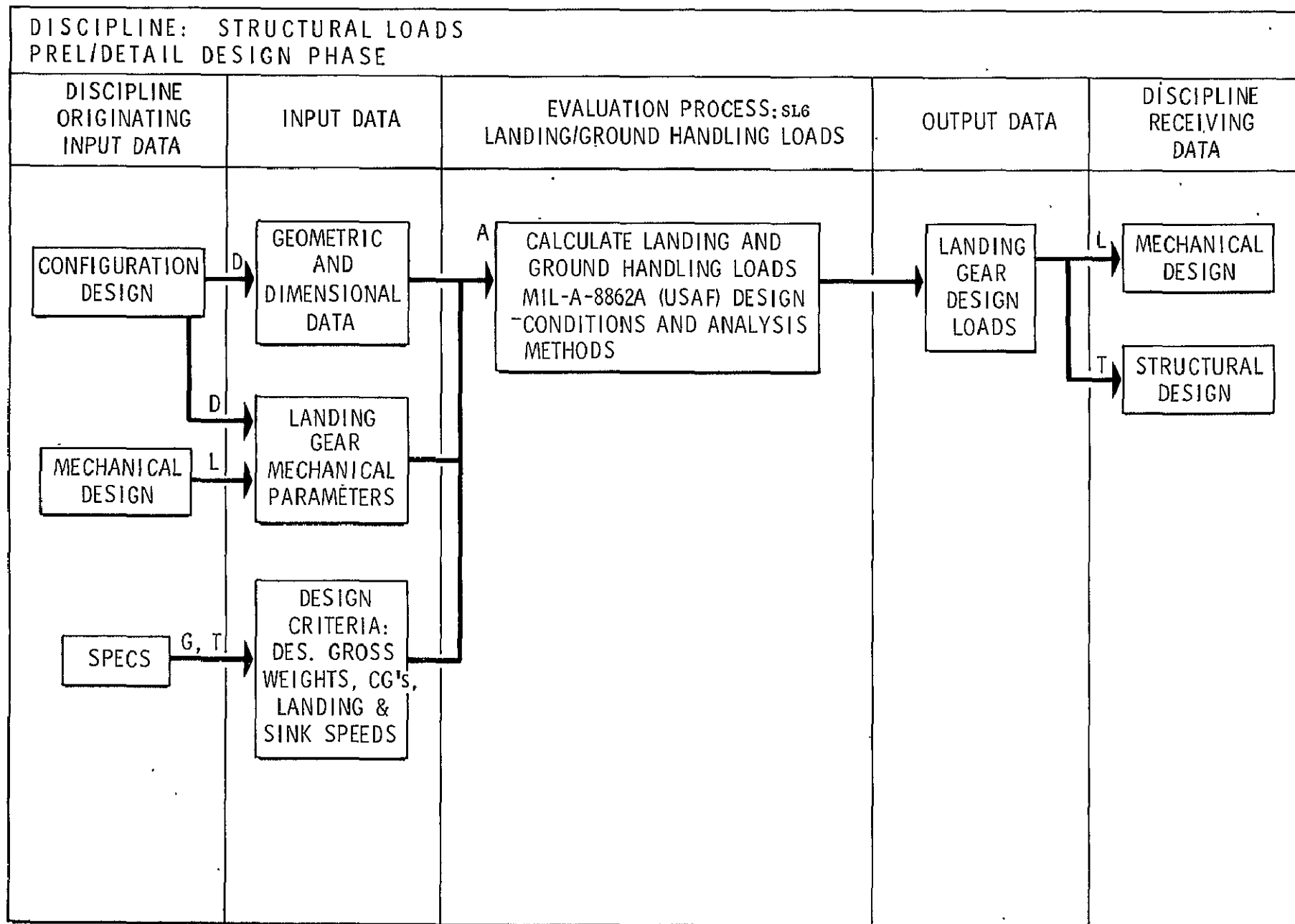


Figure 3-100. Landing/Ground Handling Loads

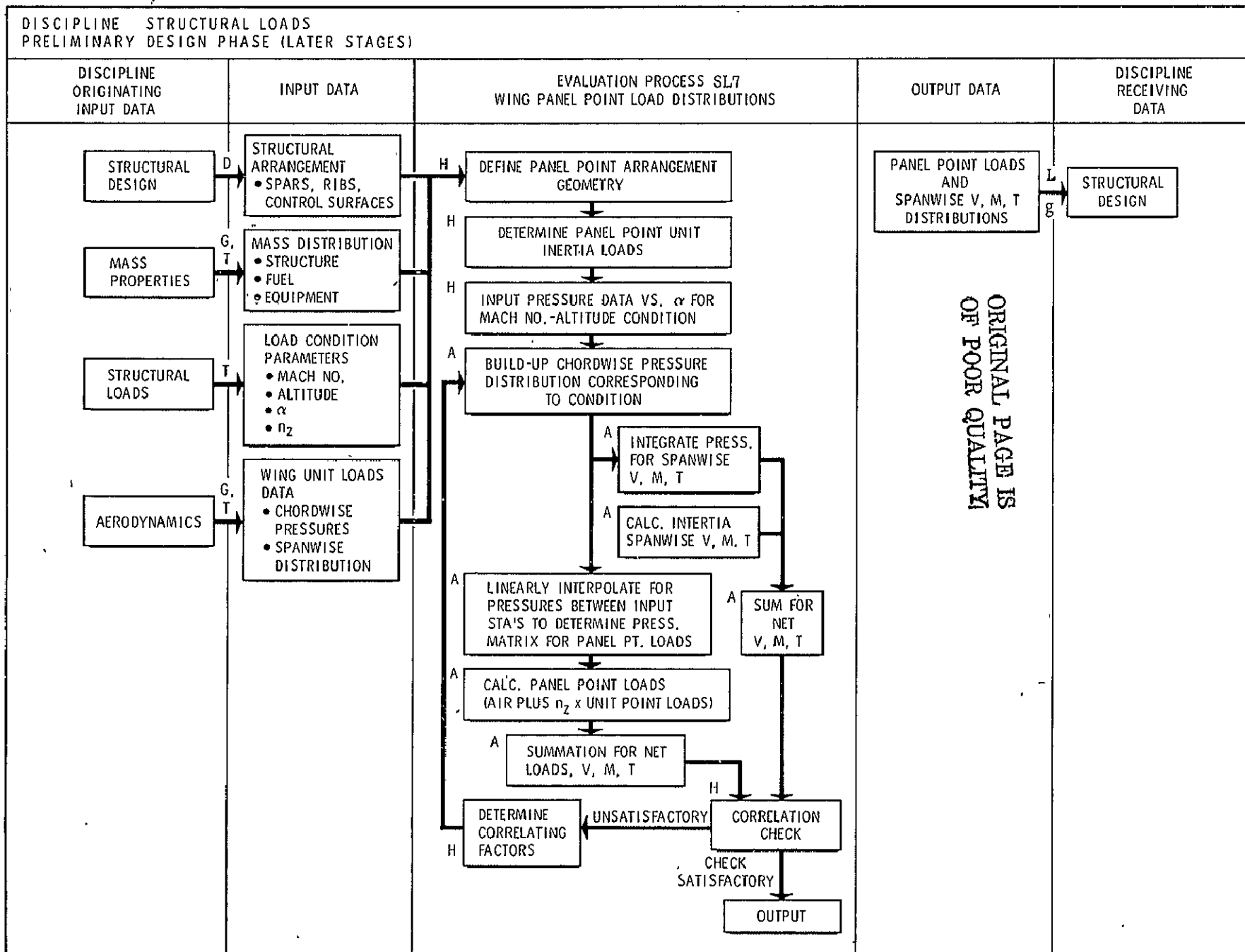


Figure 3-101. Wing Panel Point Load Distribution

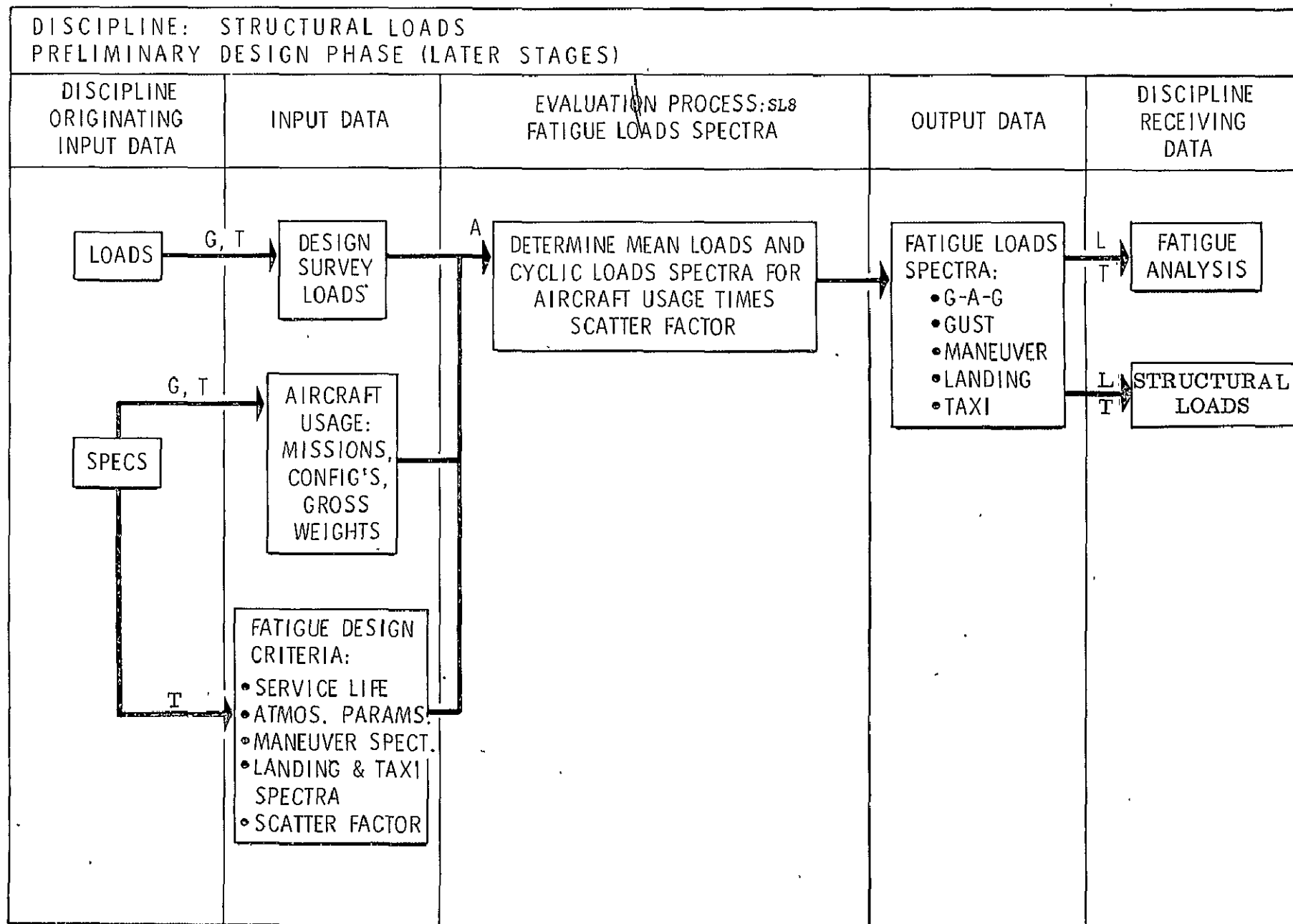
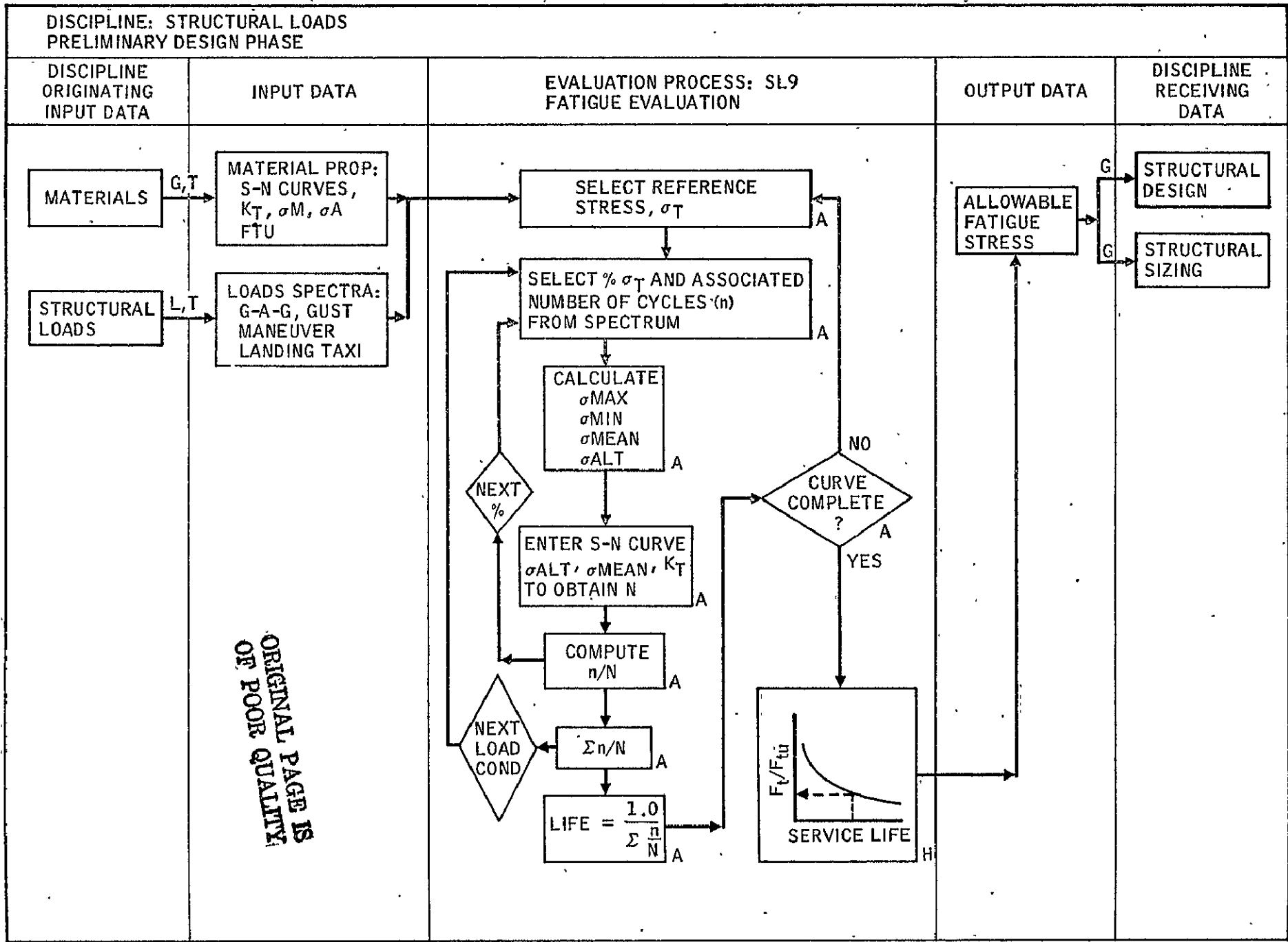


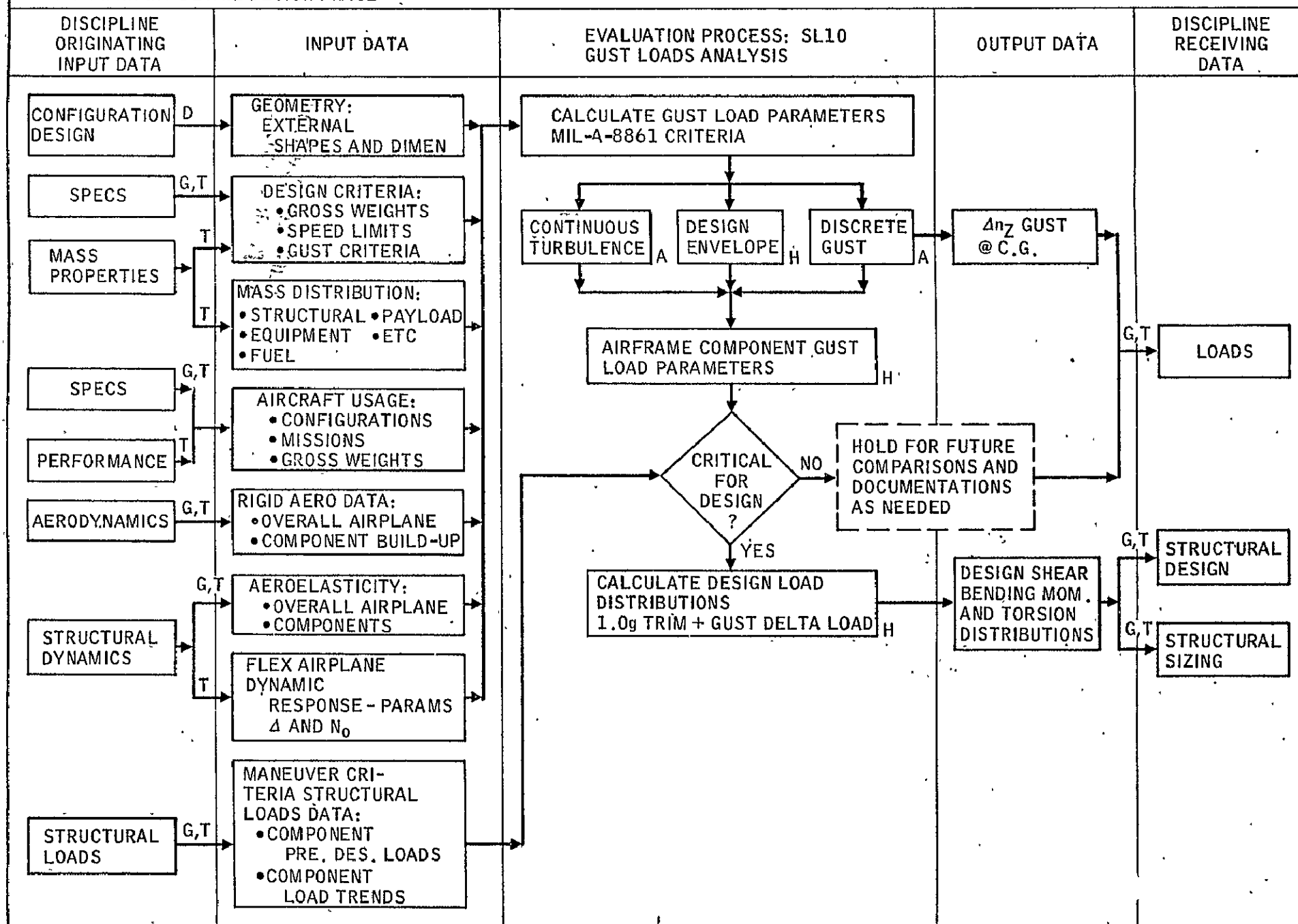
Figure 3-102. Fatigue Loads Spectra



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Figure 3-103. Fatigue Evaluation

DISCIPLINE: STRUCTURAL LOADS
PRELIMINARY DETAIL DESIGN PHASE



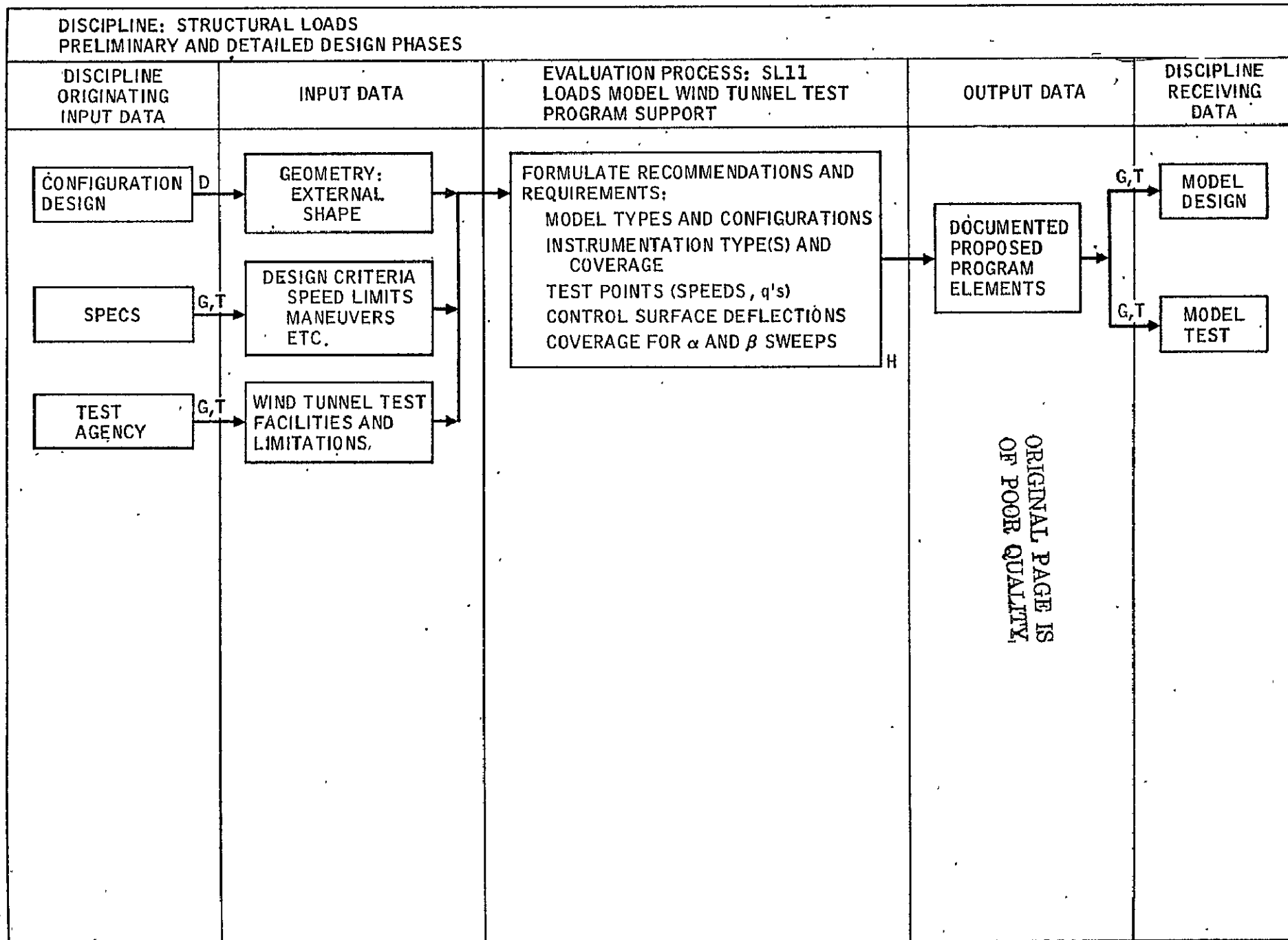


Figure 3-105. Loads Model Wind Tunnel Test Program Support

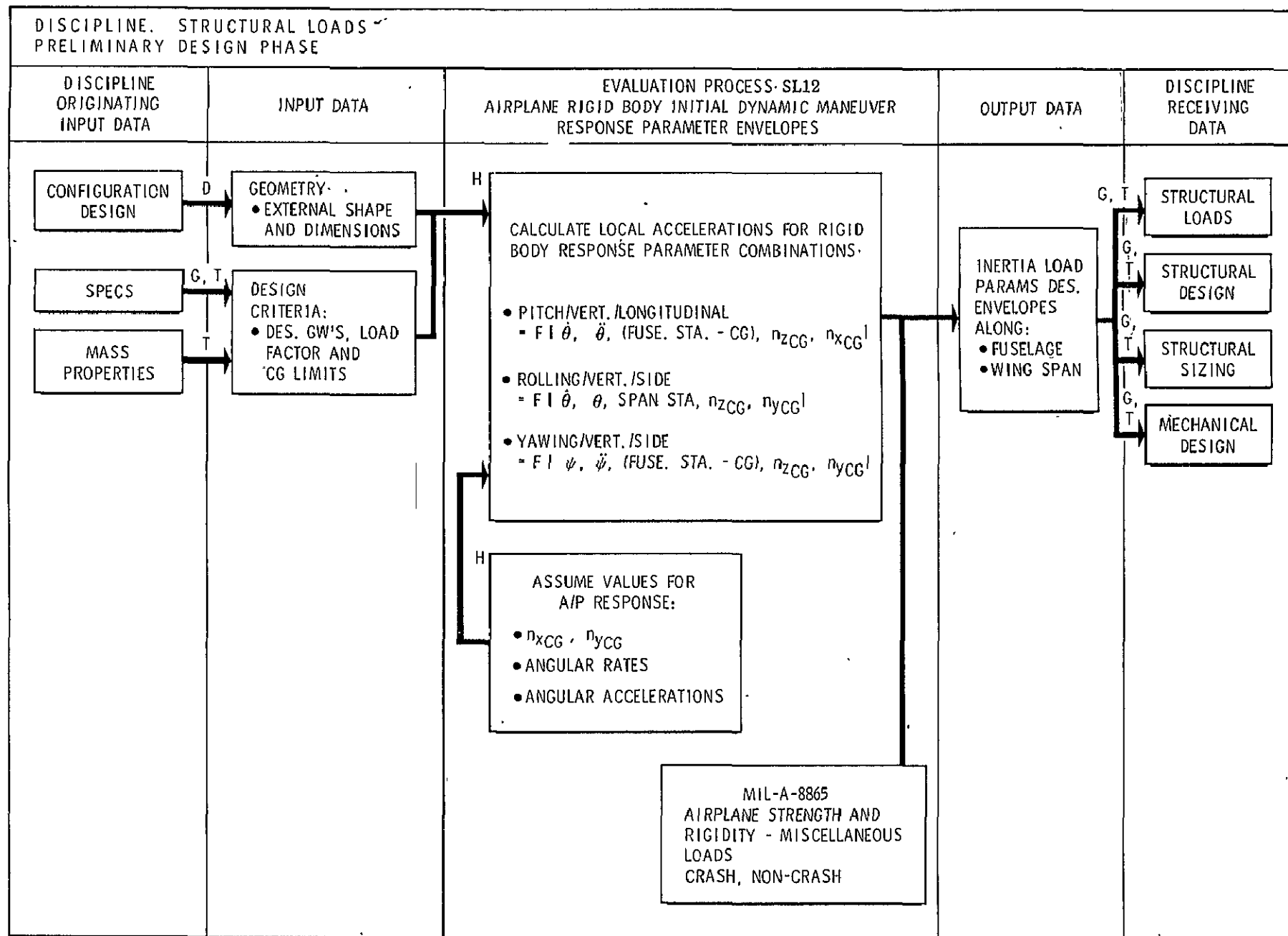


Figure 3-106. Airplane Initial Dynamics Maneuver Response Envelopes

TABLE 3-13. STRUCTURAL ANALYSIS CEP'S AND COMPUTER PROGRAMS

TASKS	CEP	Design Phase		
		C	PD	DD
Structural Arrangement and Concept Design Support.	SA1	x	x	
Multispar Box Material and Structural Concept Trade Studies.	SA2	x	x	
Advanced Composite Fuselage Section Optimization.	SA3		x	x
Finite Element Fuselage Synthesis.	SA4		x	
Material Selection.	SA5	x	x	x
Finite Element Structural Analysis.	SA6		x	x
a. Internal Loads Analysis				
b. Deflection Analysis				
c. Stress Analysis				
d. Stiffness and Flexibility Data Generation.				
Finite Element Stress Modal and Analysis.	SA7		x	x
Fuselage Multiple Station Synthesis.	SA8		x	
Wing Aeroelastic Synthesis Procedure (WASP).	SA9		x	
Preliminary Fatigue Analysis.	SA10		x	
Fatigue Analysis for Unit Damage Data.	SA11			x
Fatigue Test Evaluation and Qualification.	SA12			x
Fracture Control.	SA13		x	x
Flaw Growth.	SA14		x	x
Fracture Arrest.	SA15		x	x
Nuclear Vulnerability/Survivability Assessment.	SA16		x	x
Structural Test Planning and Test Support.	SA17		x	x
Detailed Stress Analysis.	SA18			x

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TABLE 3-13. STRUCTURAL ANALYSIS CEP'S AND COMPUTER PROGRAMS (CONT'D)

COMPUTER PROGRAMS		CEP	Design Phase		
			C	PD	DD
SEO/ Family	Family of Multi-Spar Box Analysis Procedures Used to Facilitate Material and Structural Concept Trade Studies.			x	
RJ4	Optbox II is a box beam minimum weight design algorithm.			x	
TC6	Fuselage Section Analysis.			x	
ATO	Composite Structural Box Synthesis.			x	
TL7	Finite Element Stress and Modal Analysis.			x	x
XQ4	NASTRAN Finite Element Stress Analysis.			x	x
CLAAS	Finite Element Structural Analysis.			x	x
FADES	Finite Element Fuselage Synthesis.			x	
NOVA	Skin/Stringer Sizing.			x	
WASP	Wing Aeroelastic Synthesis.			x	

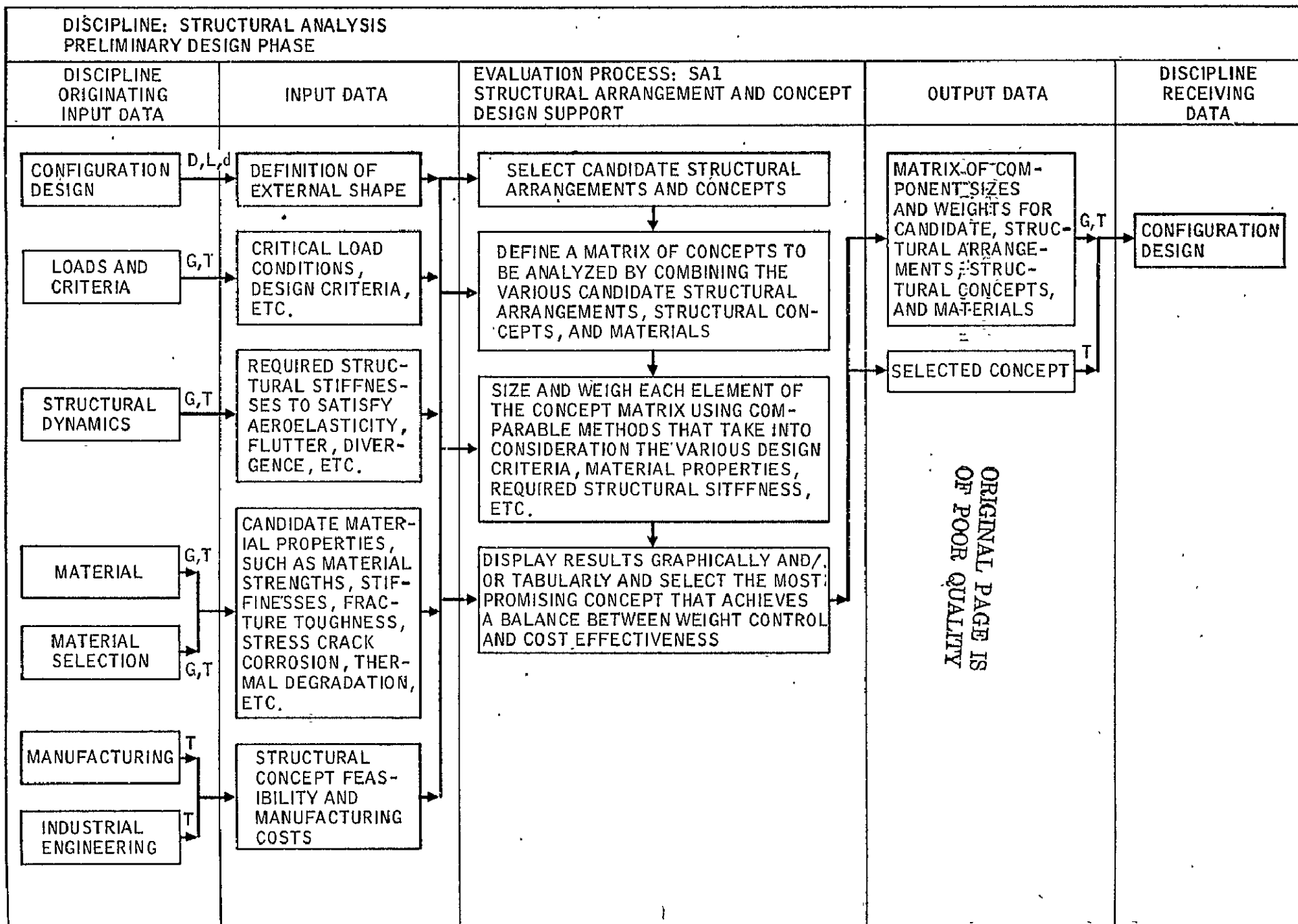


Figure 3-107. Structural Arrangement and Concept Design Support

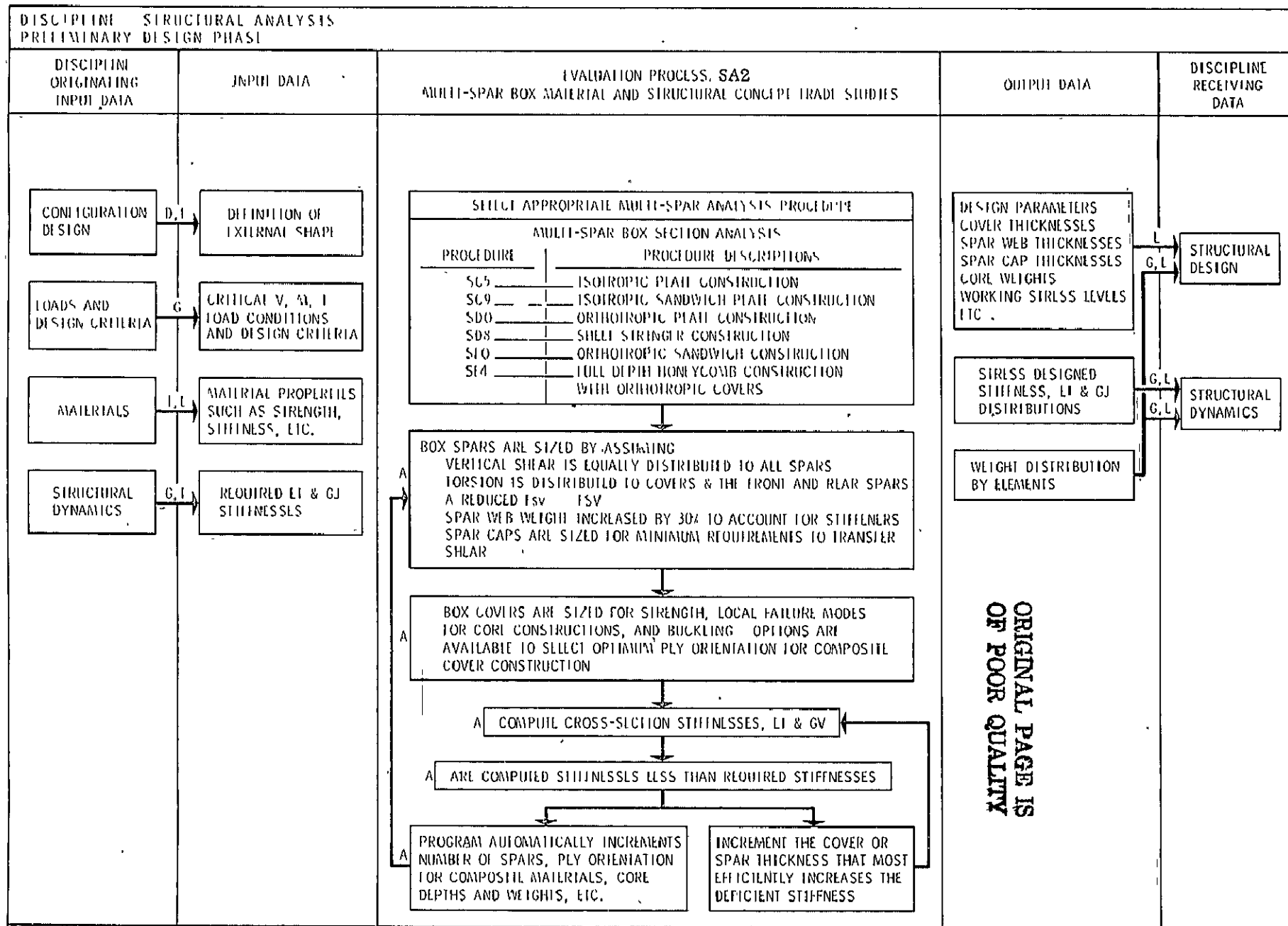


Figure 3-108. Multispar Box Material and Structural Concept Trade Studies

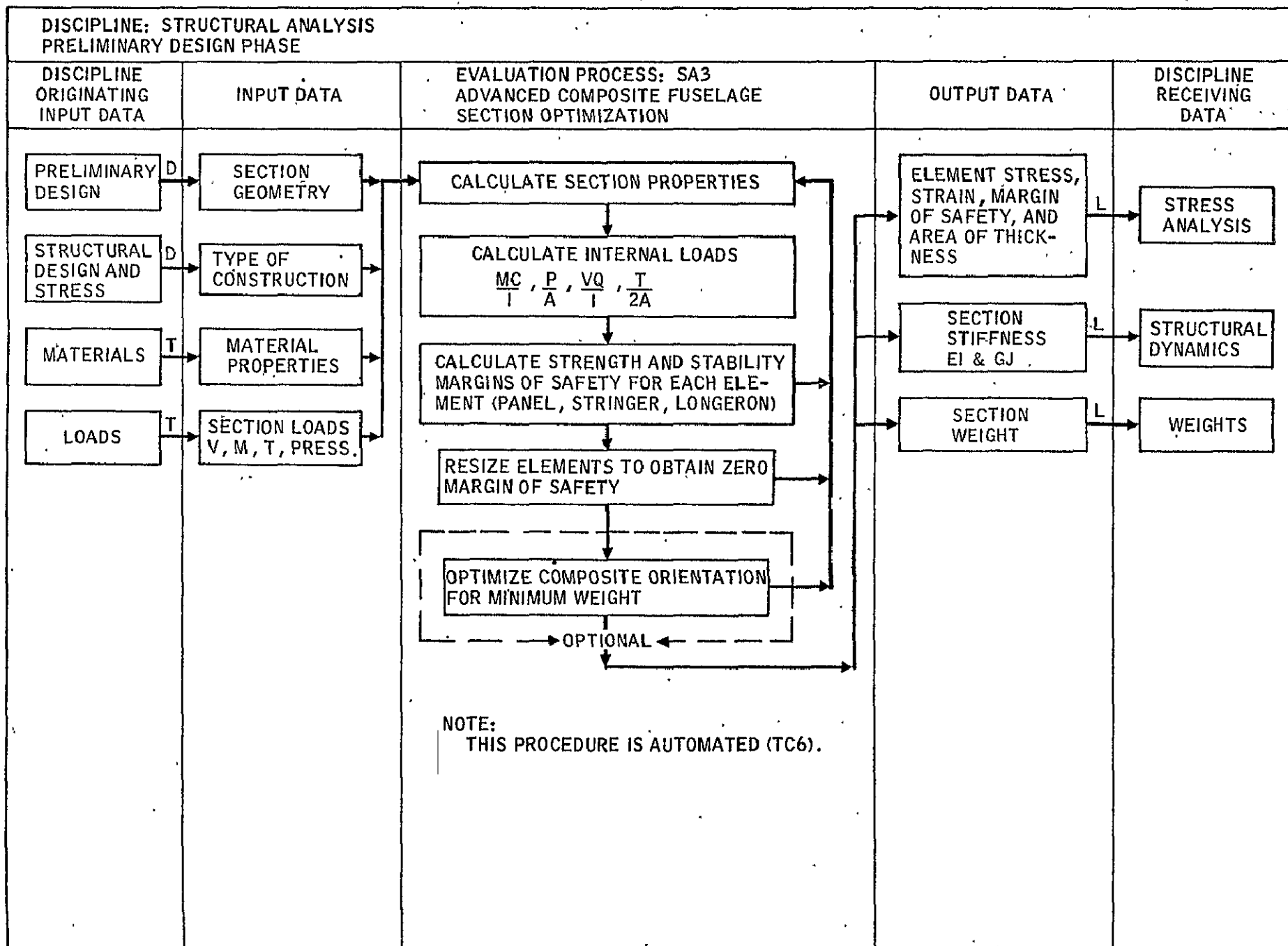
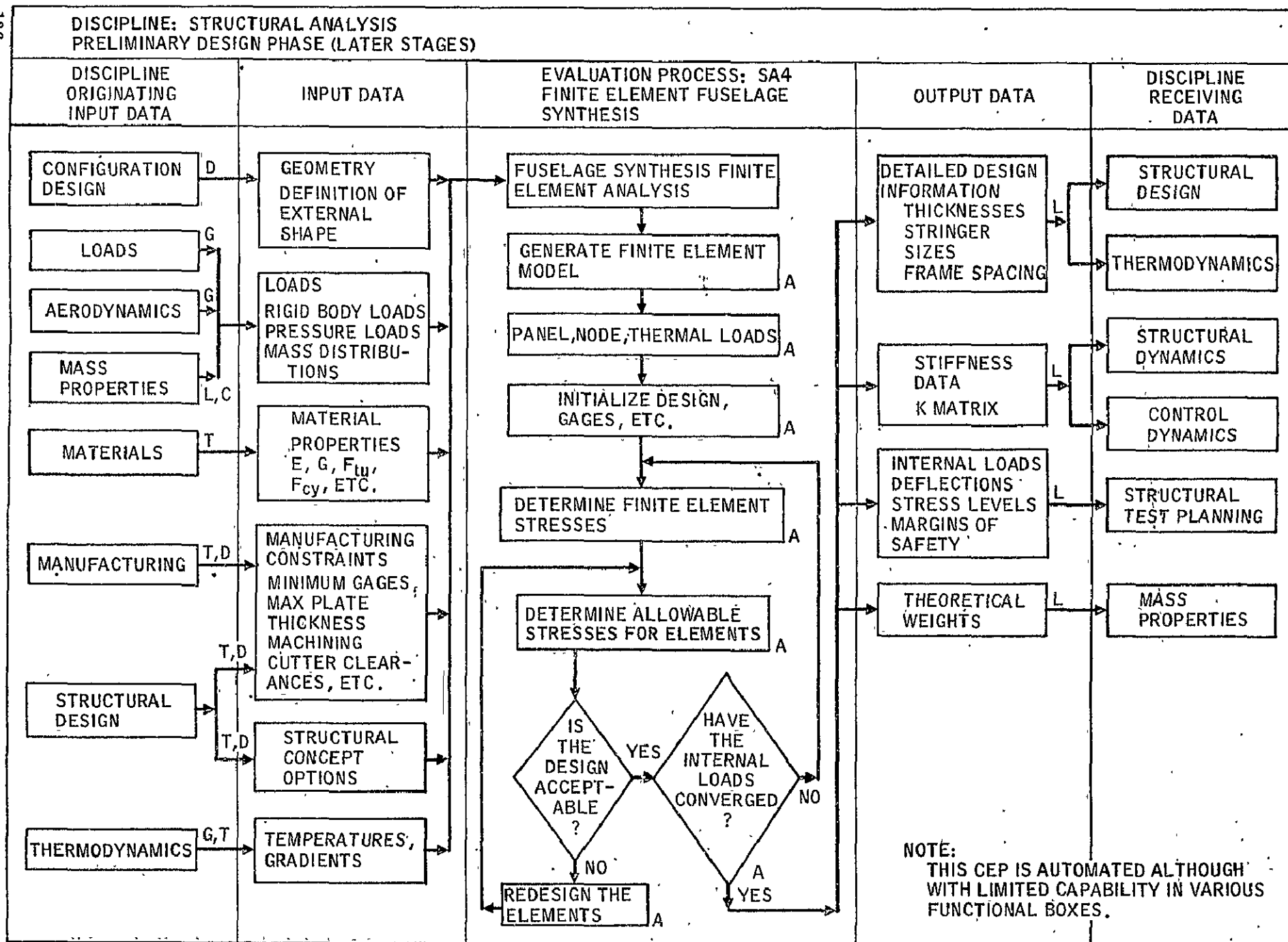


Figure 3-109. Advanced Composite Fuselage Section Optimization



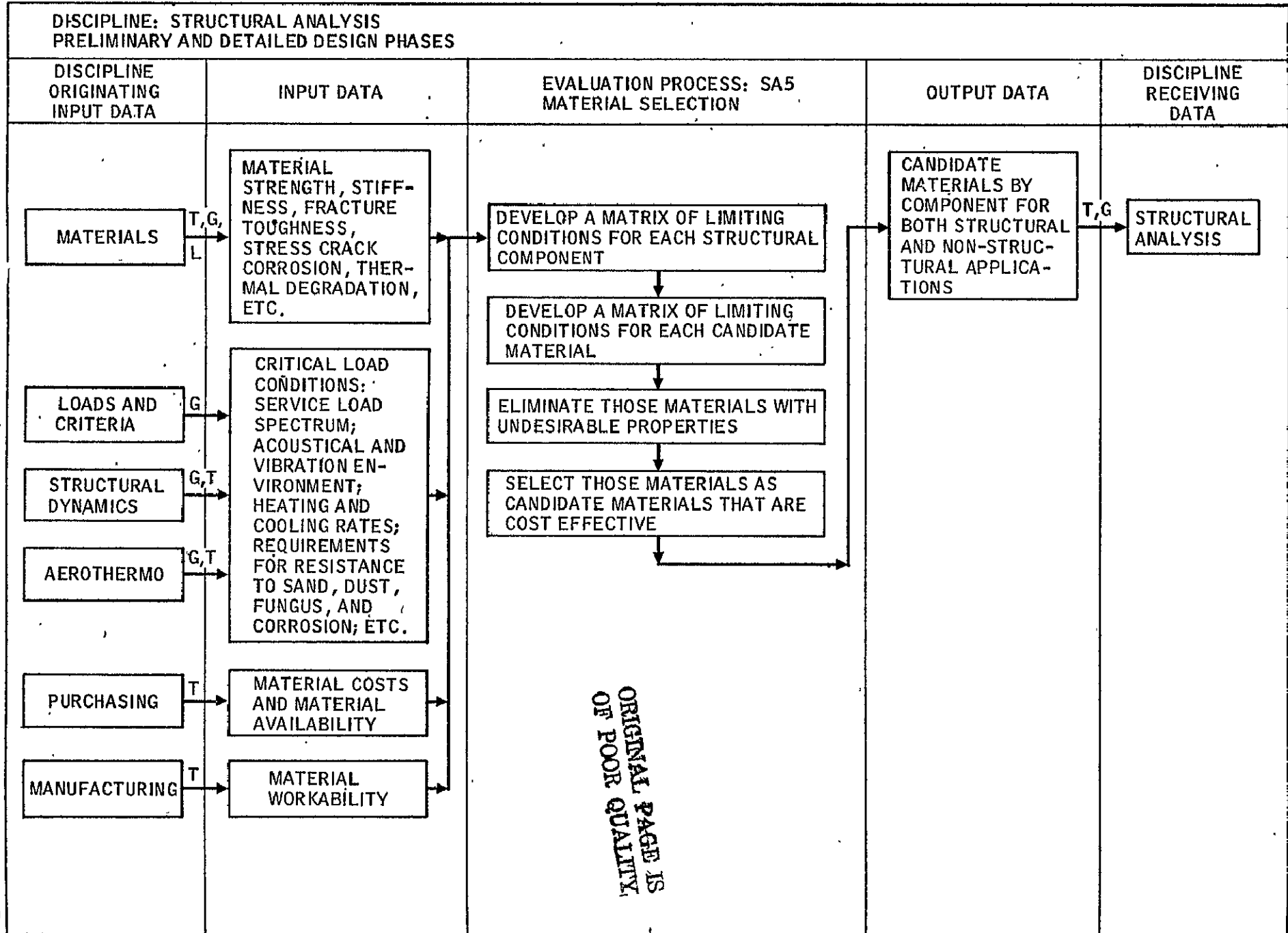
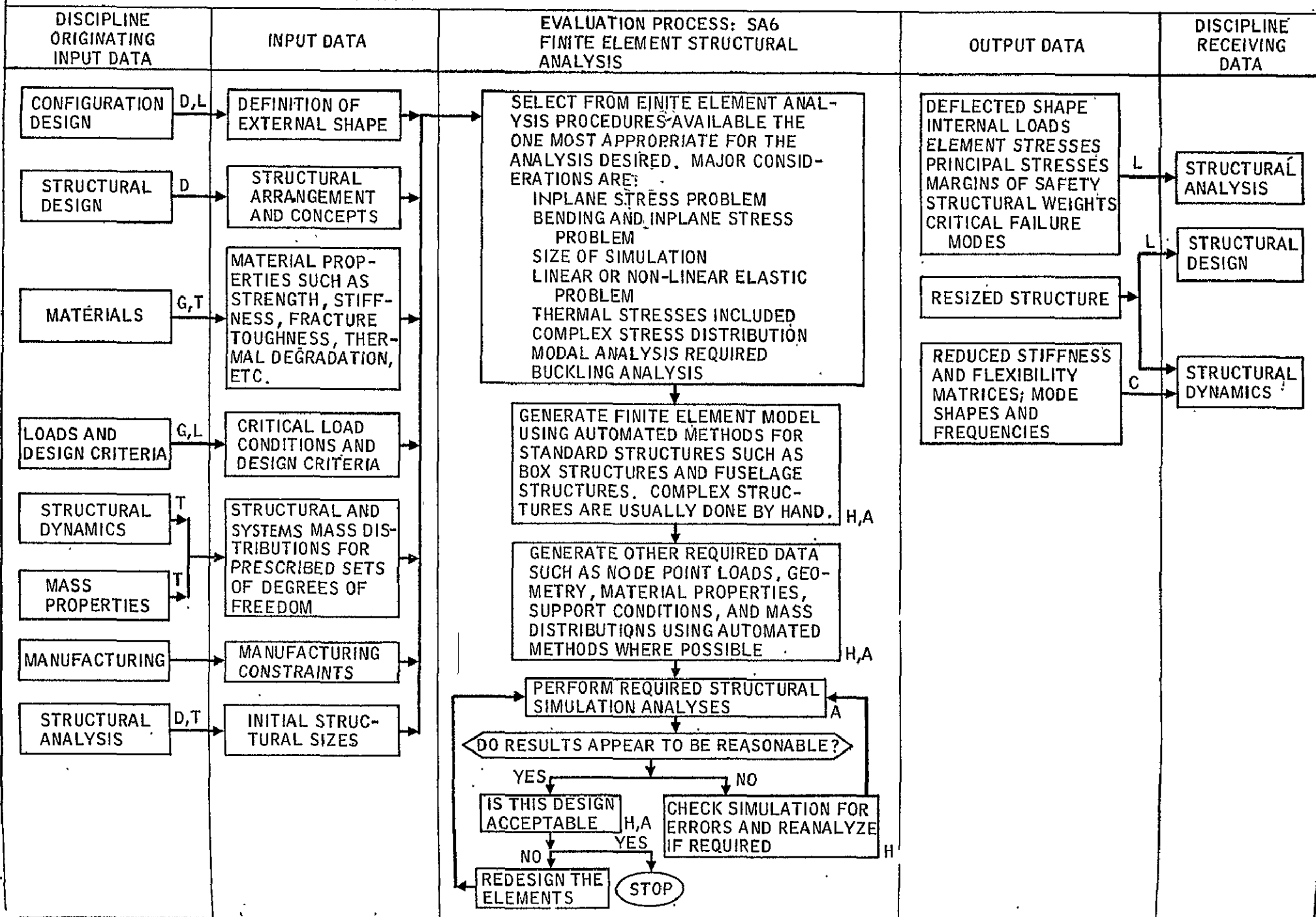


Figure 3-111. Material Selection

DISCIPLINE: STRUCTURAL ANALYSIS
PRELIMINARY AND DETAILED DESIGN PHASES



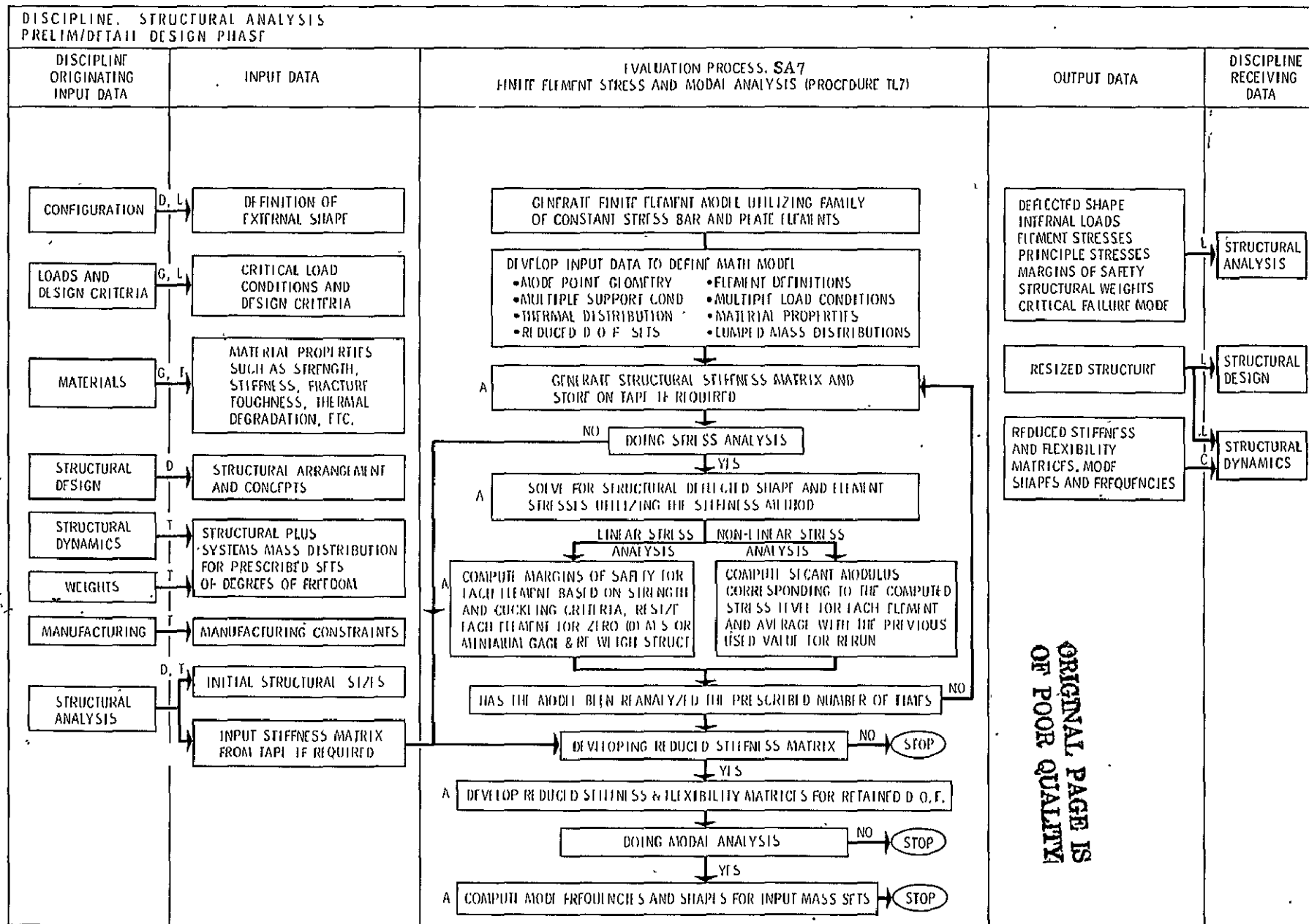
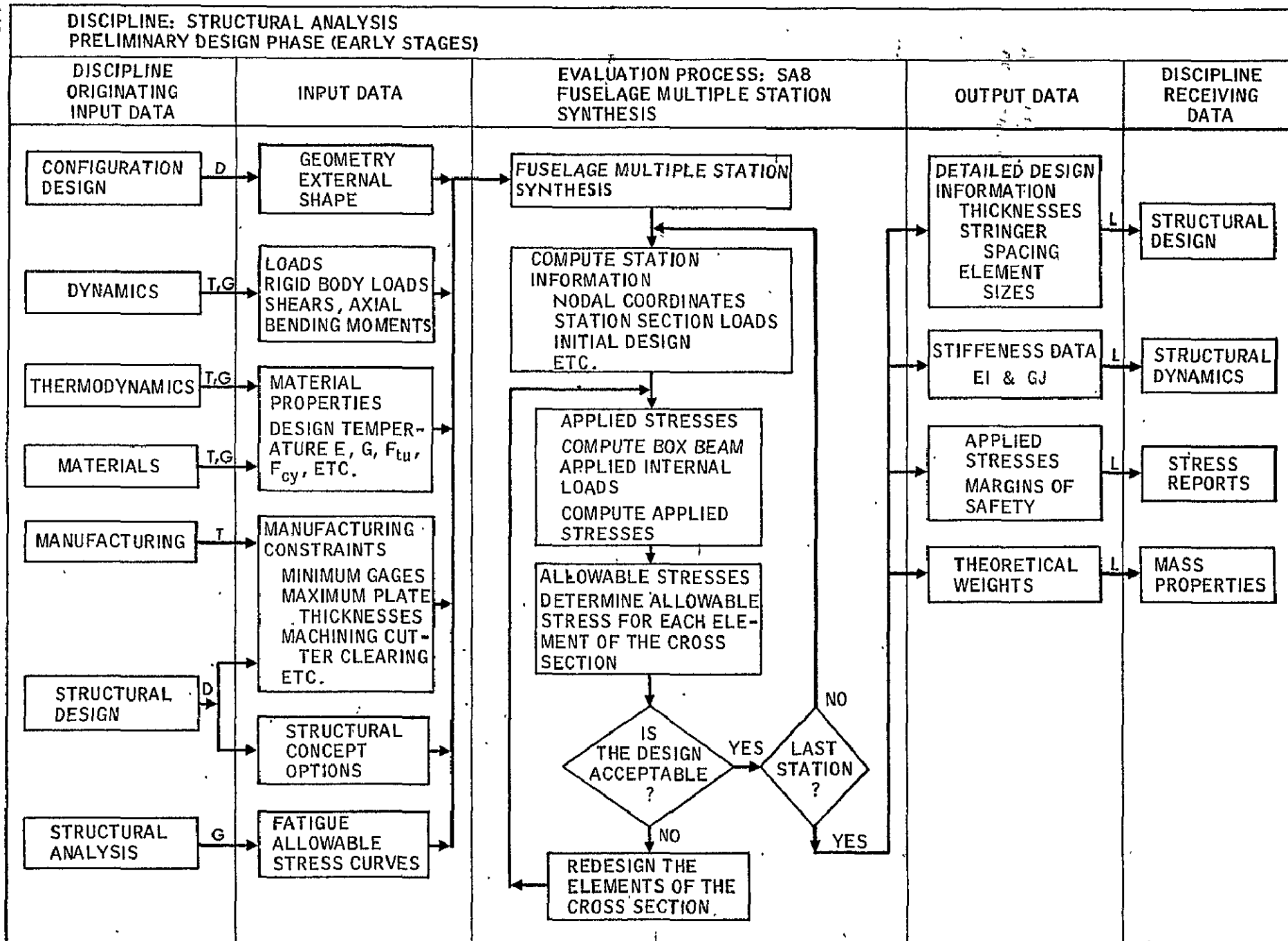


Figure 3-113. Finite Element Stress and Modal Analysis



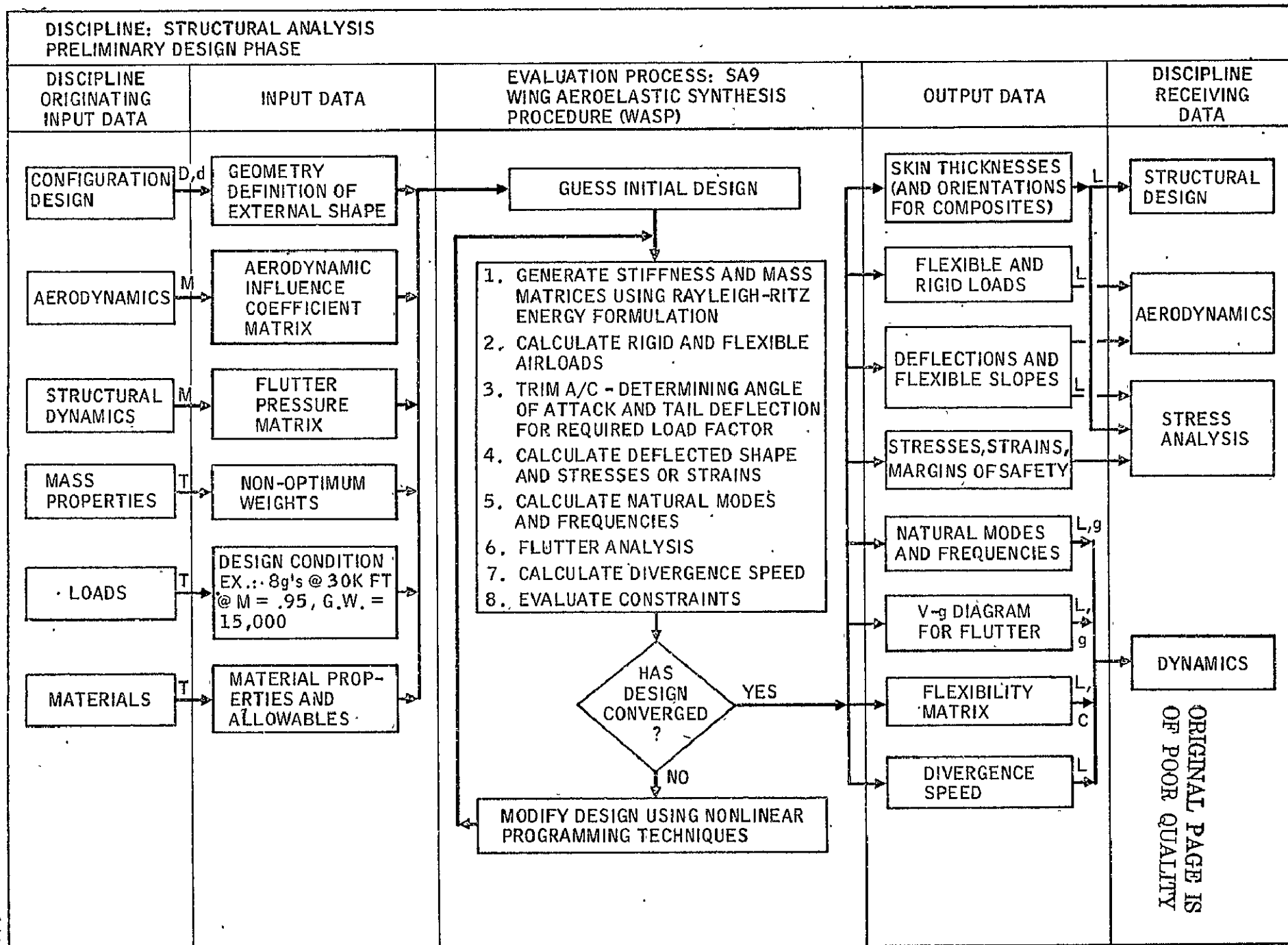


Figure 3-115. Wing Aeroelastic Synthesis Procedure (WASP)

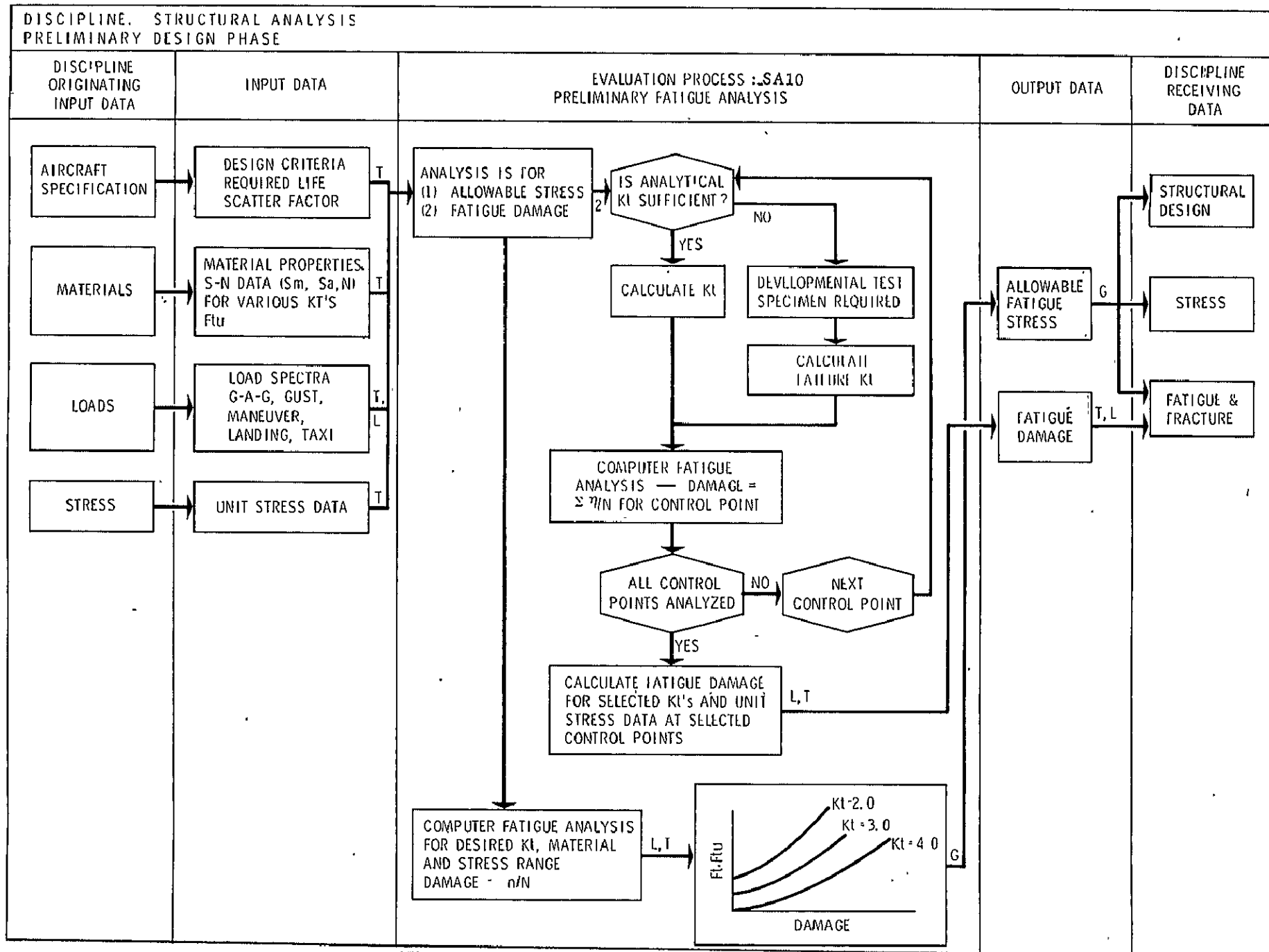


Figure 3-116. Preliminary Fatigue Analysis

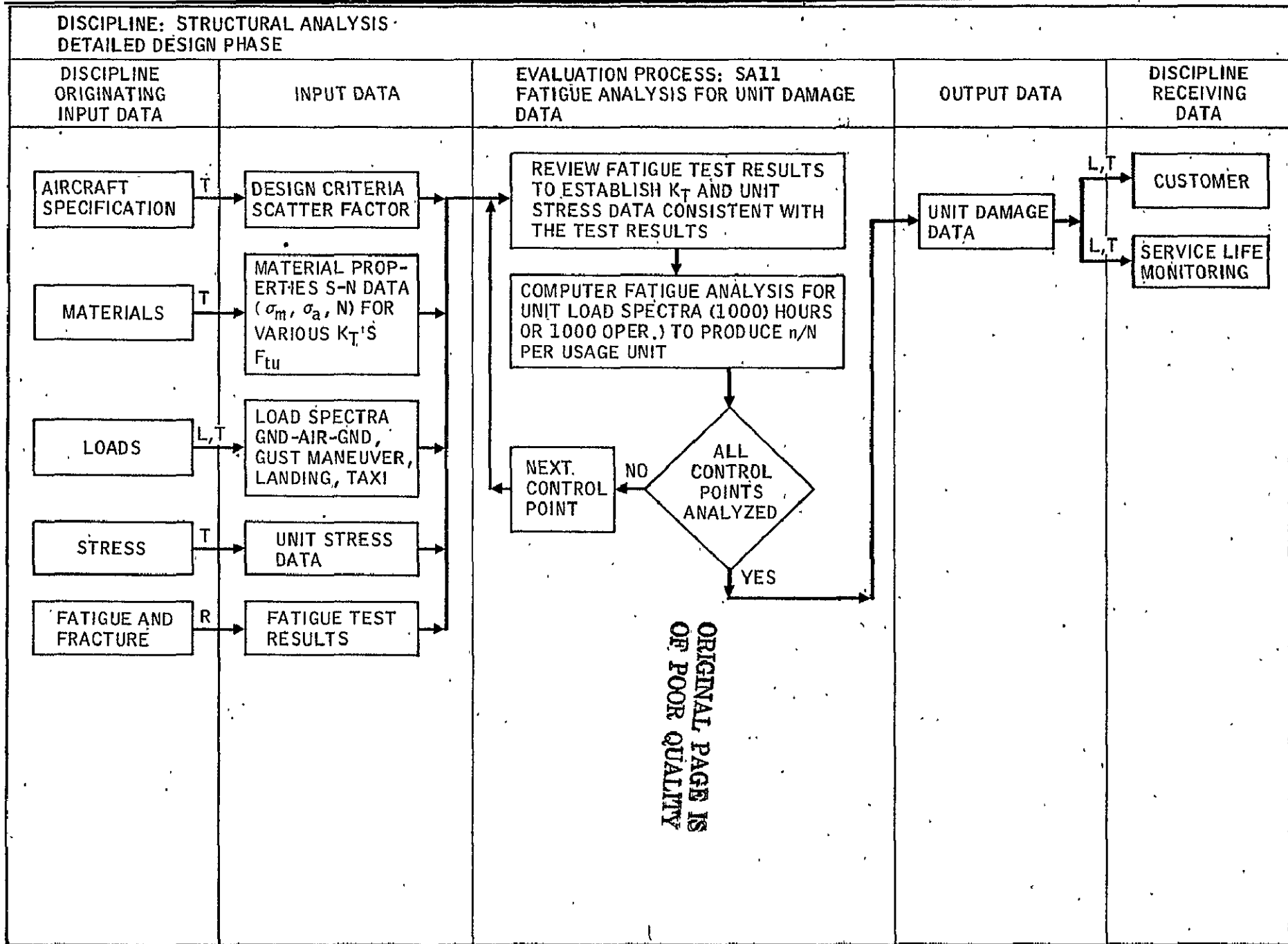
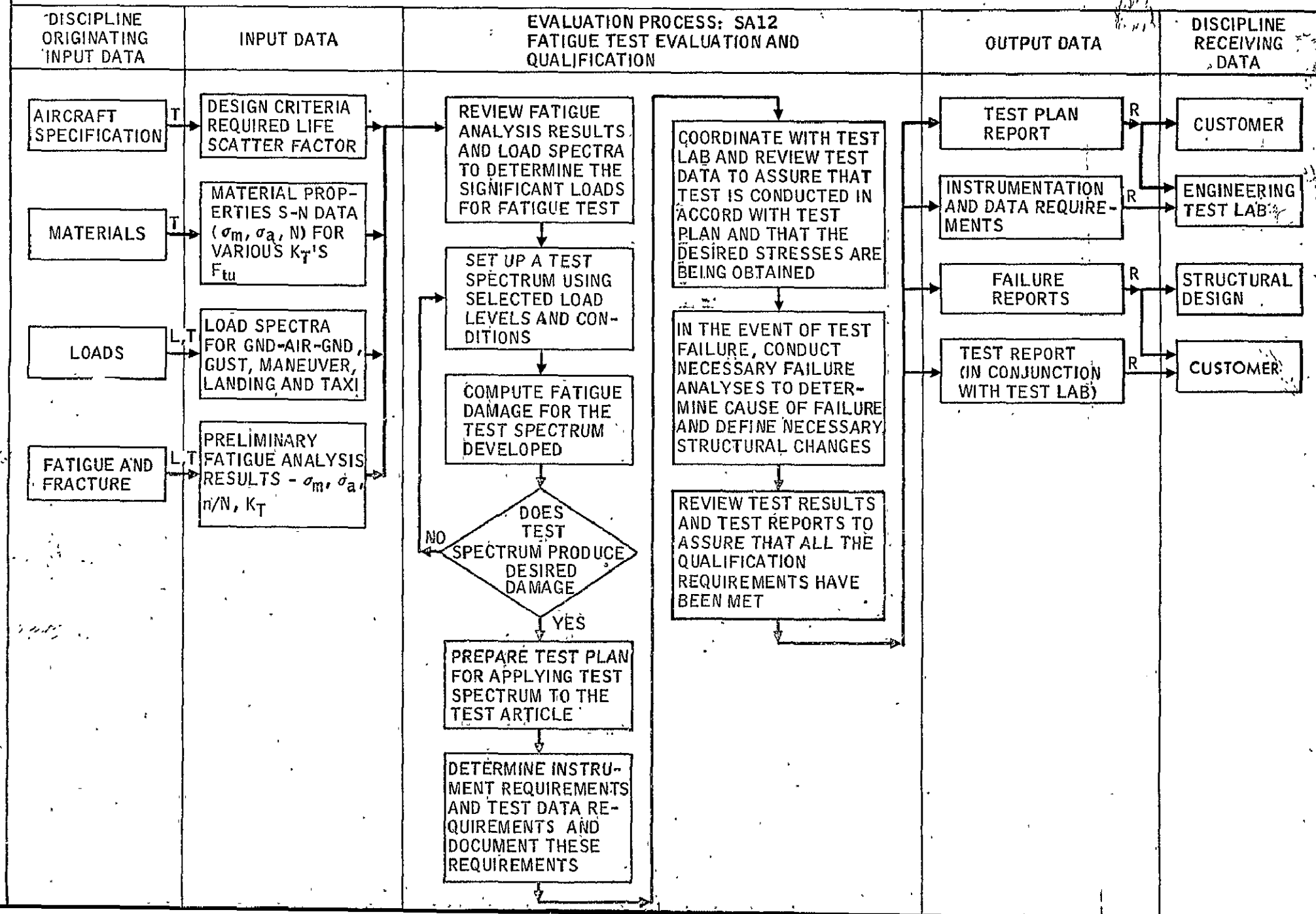


Figure 3-117.. Fatigue Analysis for Unit Damage Data

DISCIPLINE: STRUCTURAL ANALYSIS
DETAILED DESIGN PHASE



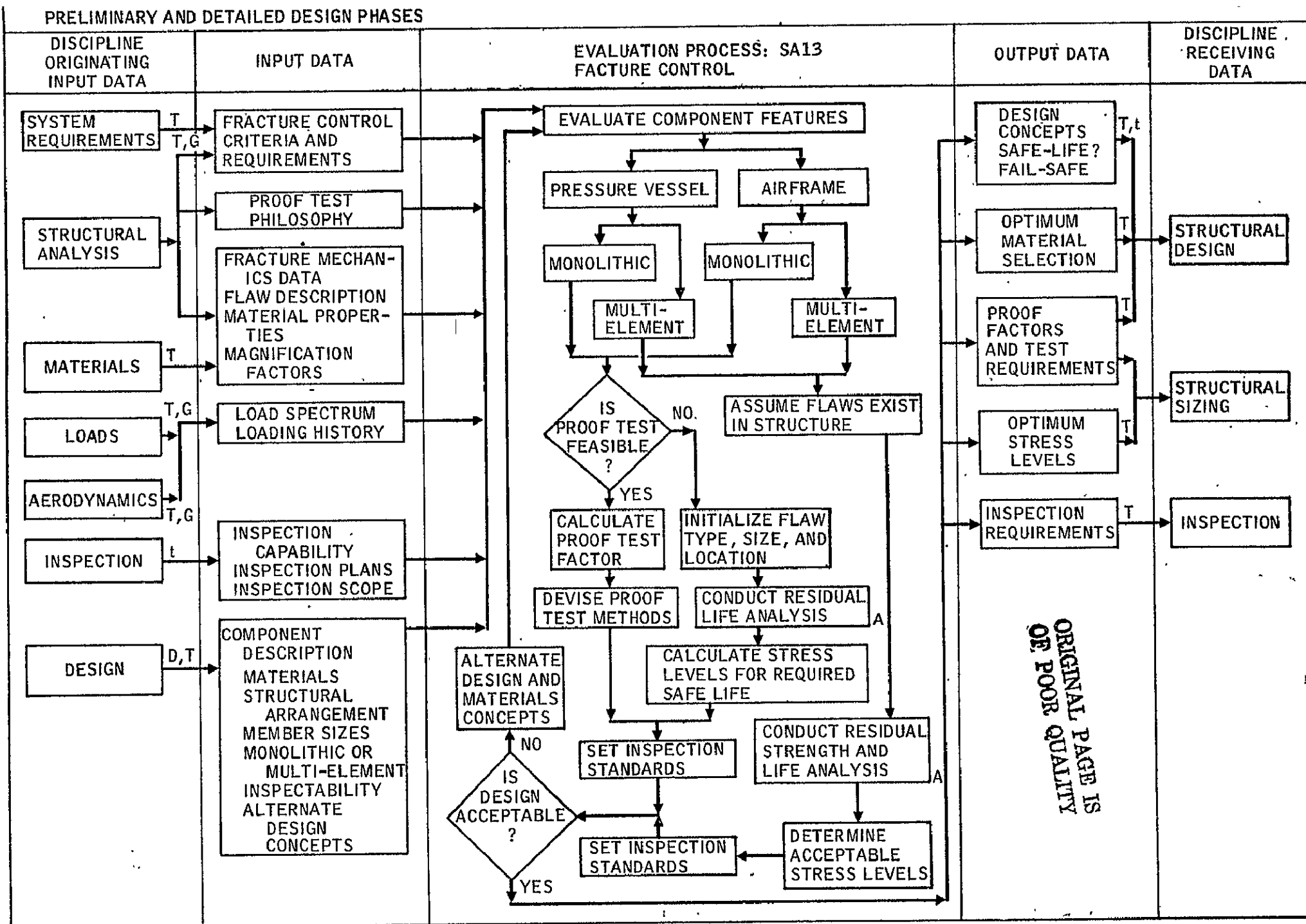
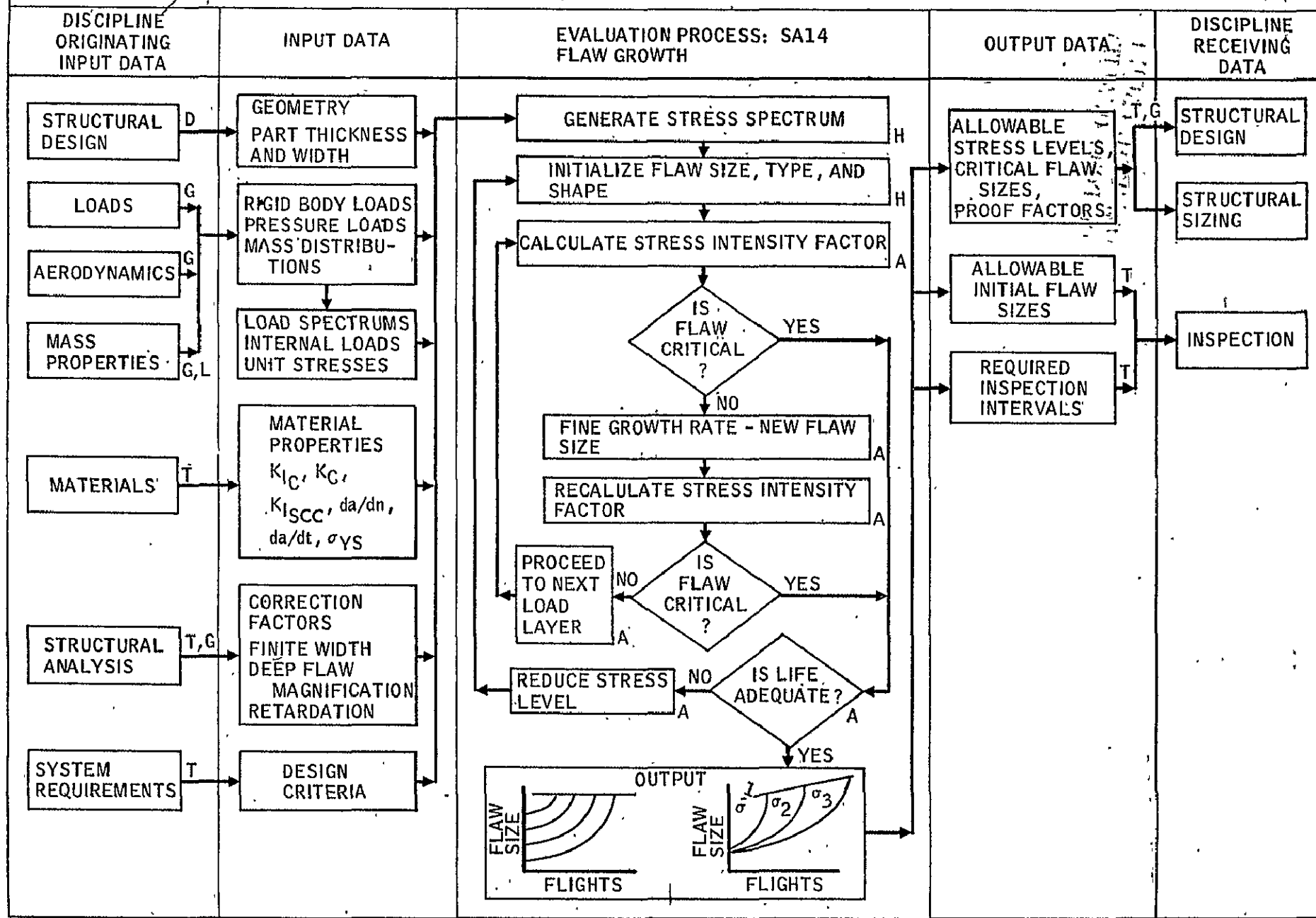


Figure 3-119. Fracture Control

DISCIPLINE: STRUCTURAL ANALYSIS PRELIMINARY AND DETAILED DESIGN PHASES



DISCIPLINE: STRUCTURAL ANALYSIS
PRELIMINARY AND DETAILED DESIGN PHASES

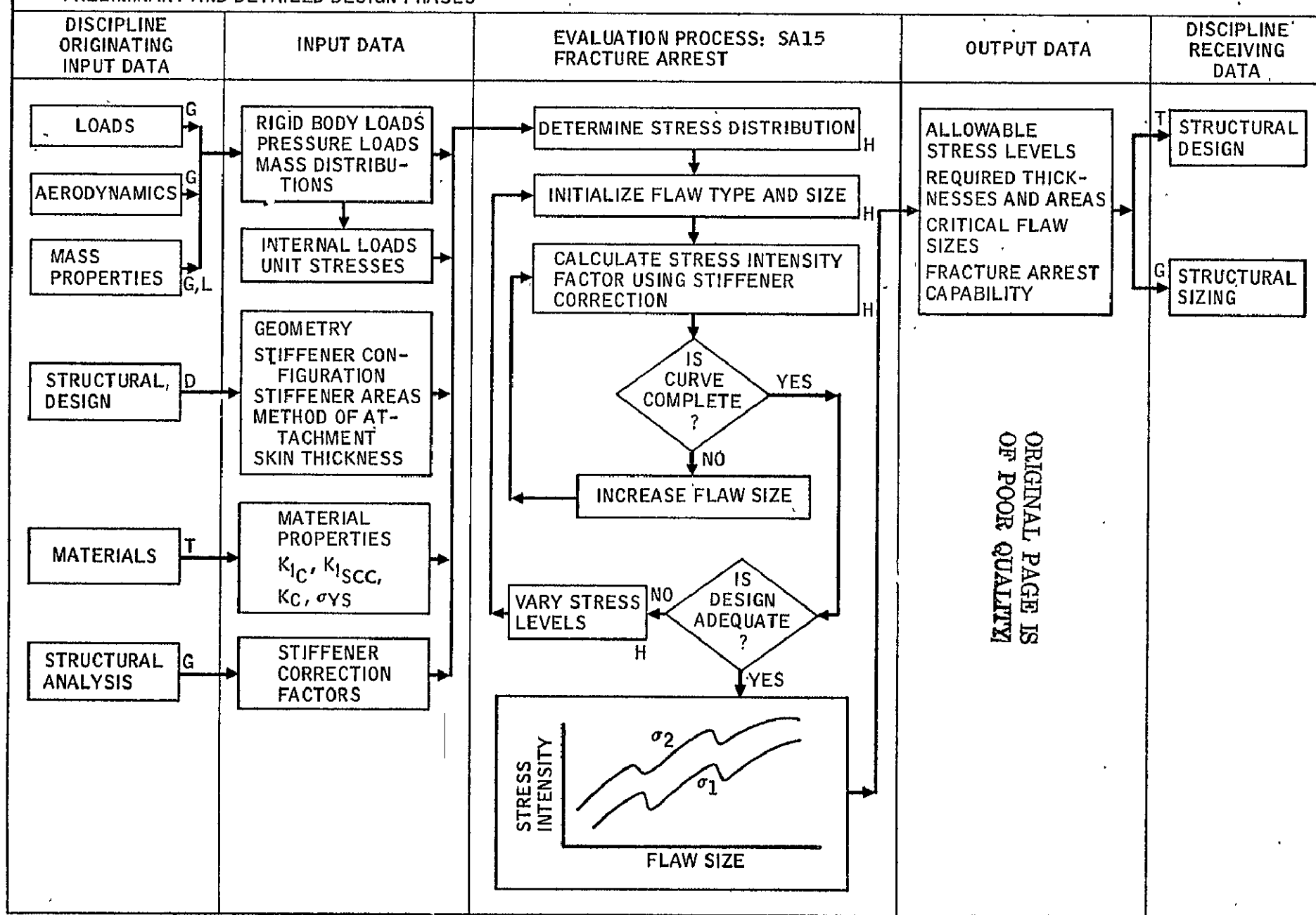
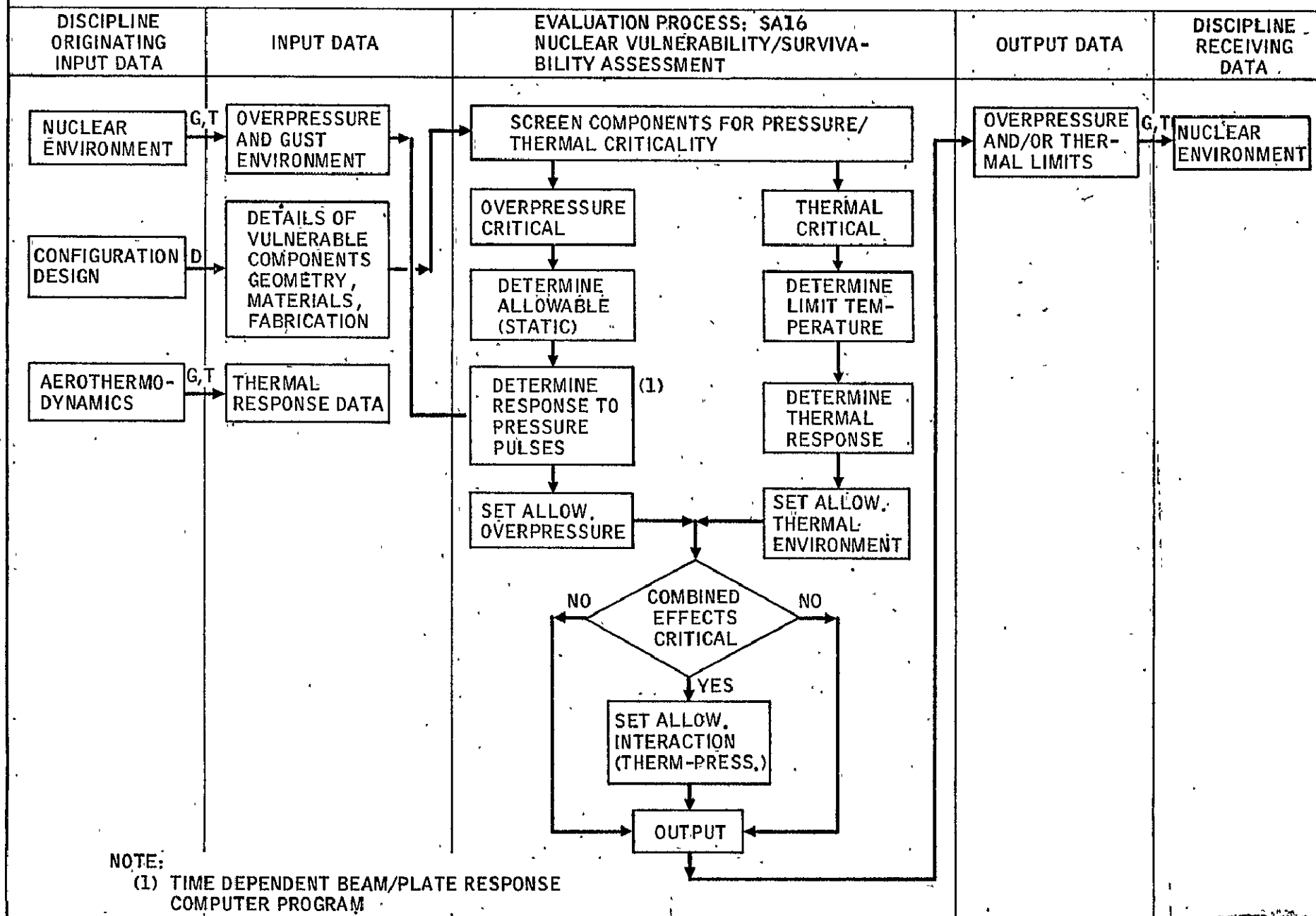


Figure 3-121. Fracture Arrest



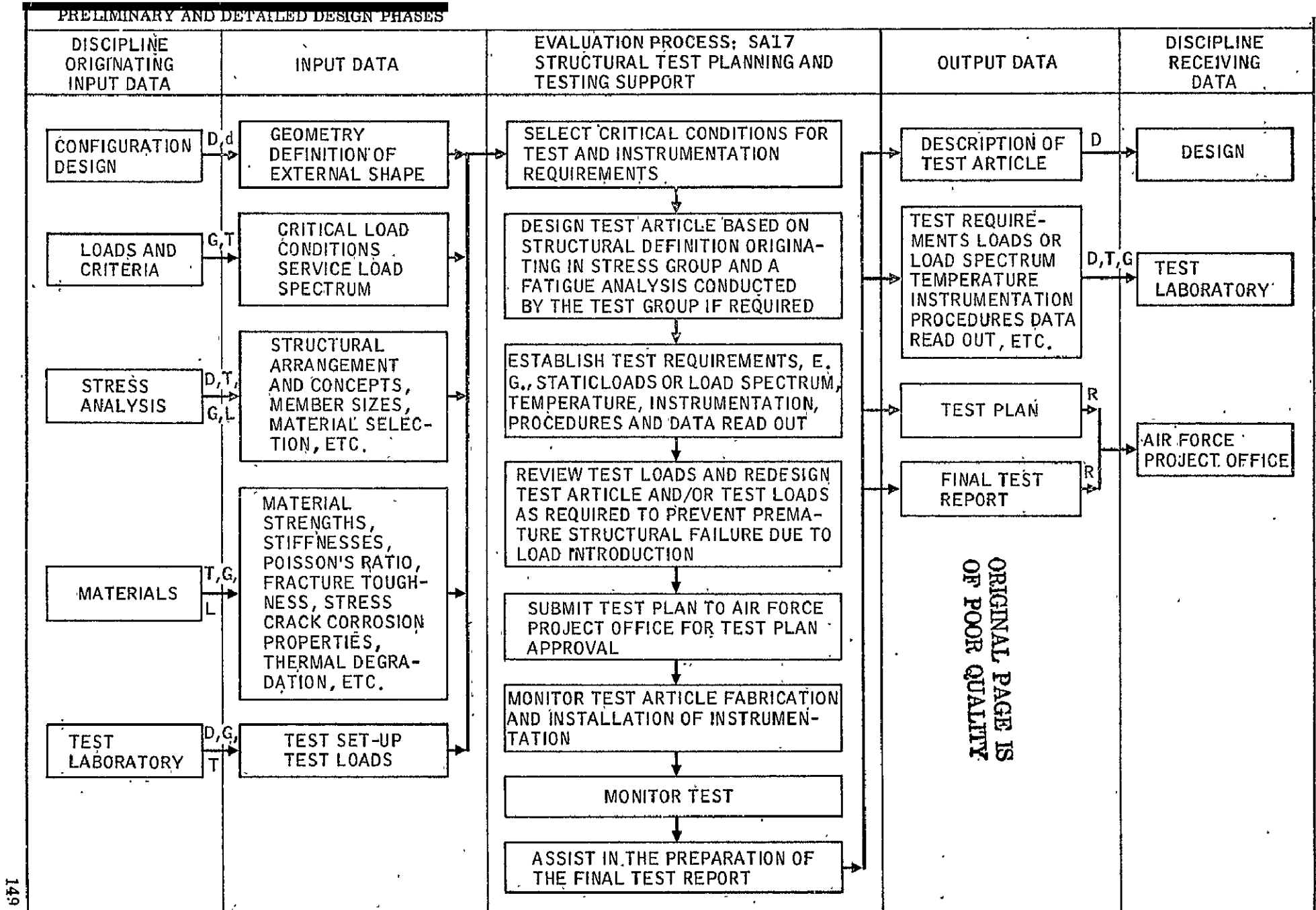


Figure 3-123. Structural Test Planning and Testing Support

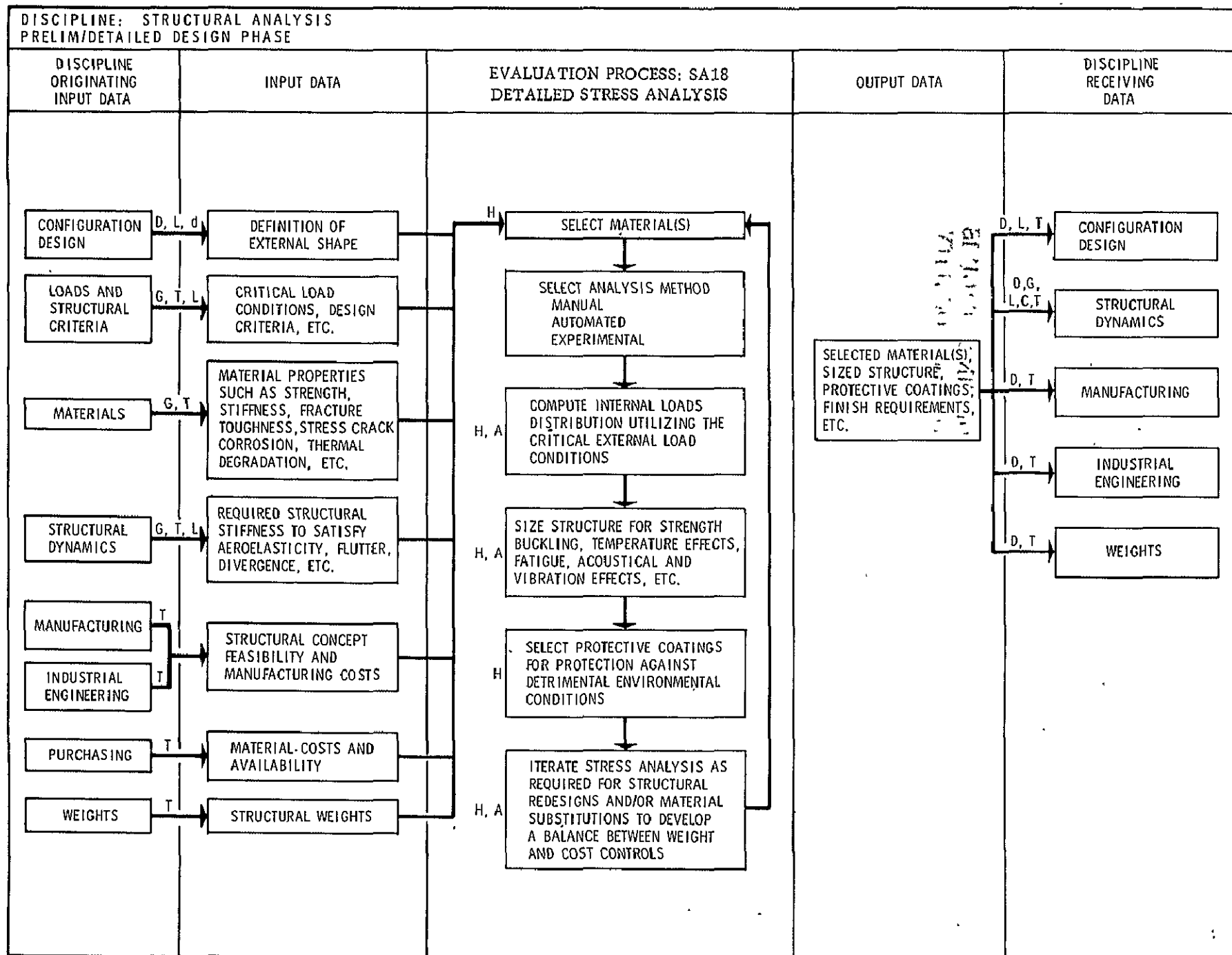


Figure 3-124 Detailed Stress Analysis

TABLE 3-14. STRUCTURAL DYNAMICS CEP'S AND COMPUTER PROGRAMS

TASKS	CEP	Design Phase		
		C	PD	DD
<u>Static Aeroelasticity</u> Compute over speed envelope surface divergence speed control surface reversal speed Predict flexible airplane aerodynamic stability derivatives Compute jig shape for cruise condition Predict flexible airplane shape for off design conditions Predict flexible airplane loads for selected flight conditions Provide support for configuration design Provide support for wind tunnel model design	SD1		x	
<u>Flutter</u> Predict airplane flutter speeds over the altitude range Provide structural analysis with stiffness requirements Provide incremental weight changes due stiffness or mass balance additions Provide sensor locations and feedback characteristic gains for flutter suppression Predict panel sizes and skin gages for panel flutter Provide support for configuration and flutter model design Plan and support ground vibration and flight flutter tests	SD2		x	x
<u>Gust Response</u> Predict fatigue and probability strength transfer function data Predict PSD response data Predict ride quality characteristics Provide quasi-steady dynamical matrices and sensor/control surface transfer functions	SD3		x	x

TABLE 3-14. STRUCTURAL DYNAMICS CEP'S AND COMPUTER PROGRAMS (CONT'D)

TASKS	CEP	Design Phase		
		C	PD	DD
<u>Gust Response (Continued)</u>				
Establish gust alleviation system requirements				
Provide support for configuration design				
Crew vibration environment				
<u>Taxi and Landing Response</u>	SD4		X	
Predict landing gear and airplane response due to discrete and random inputs				
Provide fatigue and probability strength data				
Support configuration design with landing gear characteristics				
<u>Acoustics and Vibrations</u>	SD5		X	
Predict external noise environments				
Predict noise transmission losses				
Predict internal noise environments				
Establish acoustic qualification test criteria				
Predict acoustic fatigue life of structure				
Plan acoustic fatigue life developmental tests				
Plan acoustic fatigue life verification tests				
Predict vibration environments				
Establish vibration qualification test criteria				
<u>COMPUTER PROGRAMS</u>				
BY7 Finite element structure techniques			X	X
XQ4 NASTRAN				X
RZO Family of finite element structural techniques				X

TABLE 3-14. STRUCTURAL DYNAMICS CEP'S AND COMPUTER PROGRAMS (CONT'D)

		CEP	Design Phase		
			C	PD	DD
<u>COMPUTER PROGRAMS (Continued)</u>					
AT5	Steady state finite element aerodynamic technique for wing-body-tail configurations subsonic and supersonic speeds			x	x
TS5	Steady and/or unsteady finite element aerodynamic technique for wing-tail configurations at subsonic speeds. The program also performs flutter analysis and computes the generalized aerodynamic forces for use in gust analysis.			x	x
BQ8	Steady and/or unsteady supersonic aerodynamic Mach box technique wing alone			x	x
AA8	Steady and/or unsteady kernel function technique			x	x
XOQ	Steady and/or unsteady supersonic aerodynamic Mach box technique for wing-tail configurations			x	x
SK5	Unsteady slender body aerodynamic technique			x	x
TF2	Steady and/or unsteady subsonic aerodynamic kernel function technique for wings with and without control surfaces. Also, the program performs flutter analysis and computes generalized aerodynamic forces for use in gust analysis.			x	x
ROS	Steady and/or unsteady, subsonic and supersonic aerodynamic kernel function technique for multiple lifting surface configurations.			x	x
UB3	Procedure for modifying the theoretical aerodynamic matrix (AT5) using experimental pressure data.			x	x
ROU	Procedure used to assemble experimental pressure data from tape into UB3.			x	x
SZ4	Steady state aeroelastic procedure. This program assembles the aerodynamic and structural technique to solve for the flexible aerodynamic characteristics.			x	x

TABLE 3-14. STRUCTURAL DYNAMICS CEP'S AND COMPUTER PROGRAMS (CONT'D)

		CEP	Design Phase		
			C	PD	DD
<u>COMPUTER PROGRAMS (Continued)</u>					
TH3	Program is used to combine procedures AA8 and SK5 to formulate the flutter solution for a complete air-plane system.			x	x
BS5	Curve fitting and interpolation procedure. This program is used to interpolate the modes for slopes and deflections at the aerodynamic control points for the AA8 and BQ programs.			x	x
BS6	Program generates the data required to include the effects of a stability augmentation system (SAS) in the analysis of the dynamic response of an elastic vehicle.			x	x
TM9	Curve fitting and interpolation procedure is a modification of BS5 for the TF2 program.			x	x
SB2	Program is used to compute the response of an aircraft to random atmospheric turbulence and/or discrete gusts. The program also has provision for including gust alleviation systems.			x	x
SY1	A flutter optimization program used to resize finite elements of a structural simulation to obtain the required flutter speed with reduced weight.			x	x
CSMP	A taxi and landing procedure used to compute the gear and airframe response.			x	x
BM9	Computes constant sound pressure level contours for overall and octave band frequencies in a jet near noise field.			x	
A1X	Computes sound pressure levels from engine and aerodynamic data. Computes panel response to the noise and compares with allowable acoustic fatigue life.			x	x
UA4	Computes far-field noise levels from basic engine parameters.			x	x

TABLE 3-14. STRUCTURAL DYNAMICS CEP'S AND COMPUTER PROGRAMS (CONT'D)

COMPUTER PROGRAMS (Continued)		CEP	Design Phase		
			C	PD	DD
A4N	Computes the effective perceived noise level EPNL, footprint of an aircraft flyover using engine noise characteristics from measurements or predictions by UA4.			x	x
A4O	Computes EPNL at any given point on the centerline of the aircraft takeoff or landing flight paths.			x	x
A4P	Computes point along the sideline where the EPNL is greatest.			x	x
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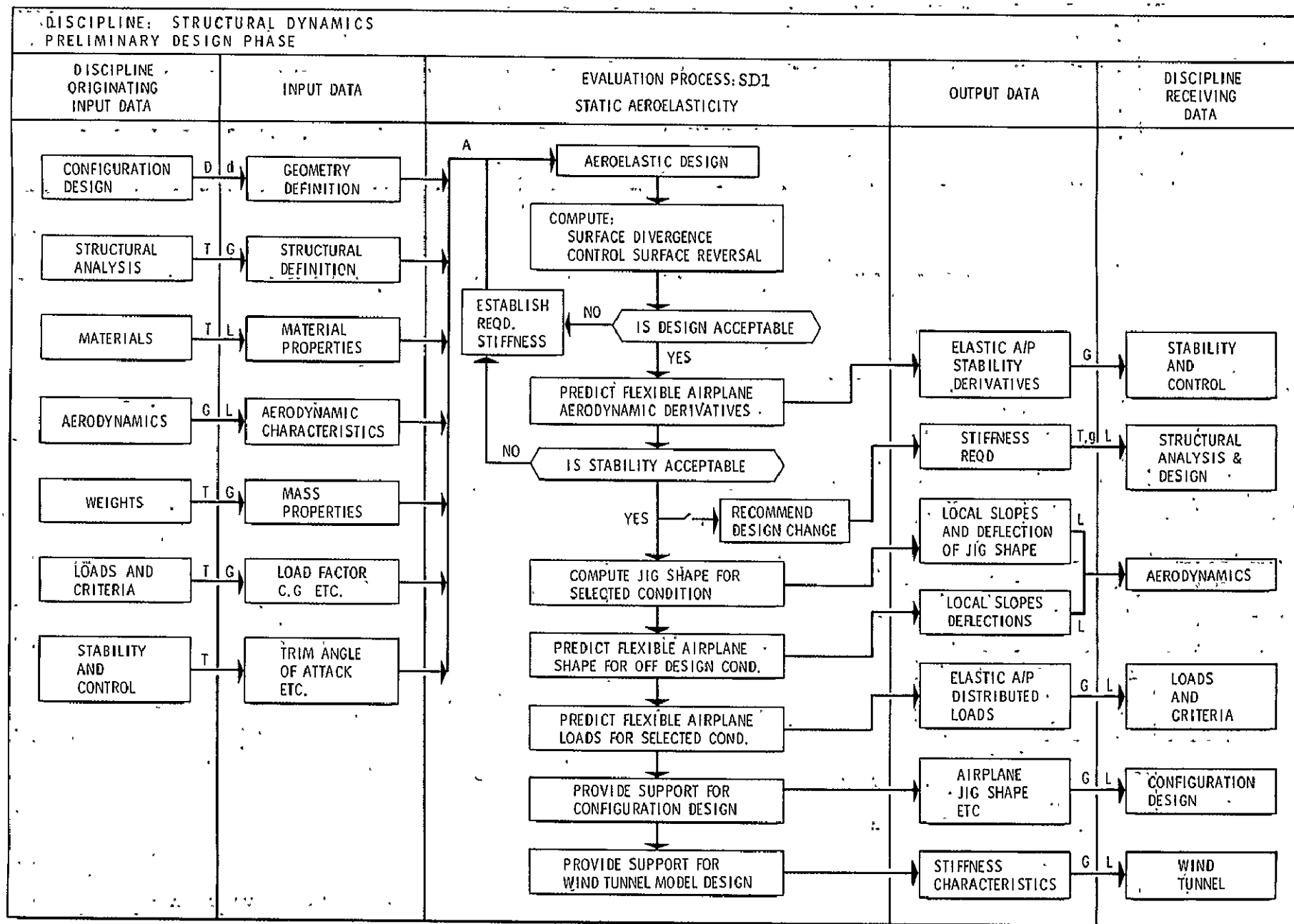


Figure 3-125. Static Aeroelasticity

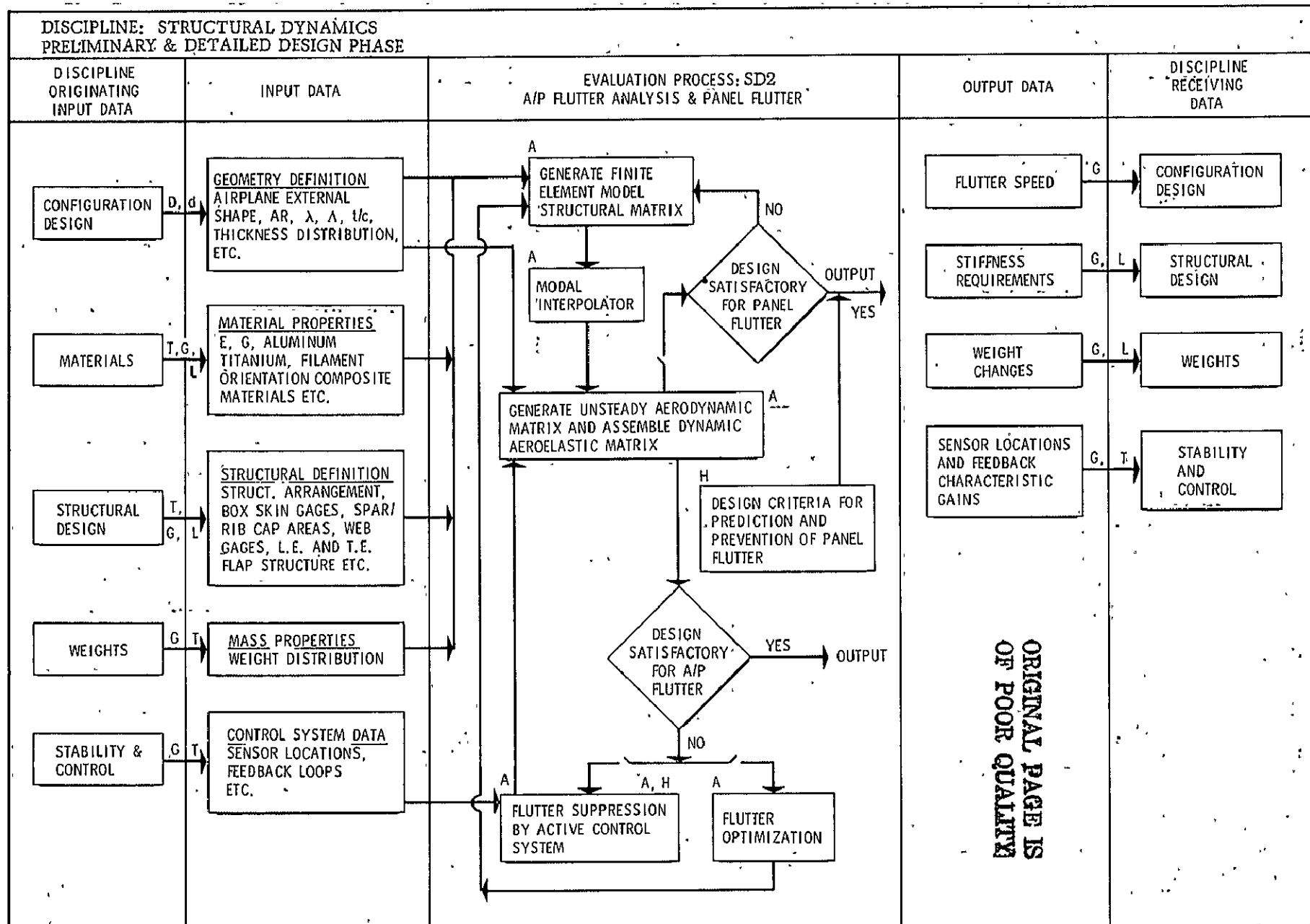


Figure 3-126. Aircraft Flutter Analysis and Panel Flutter

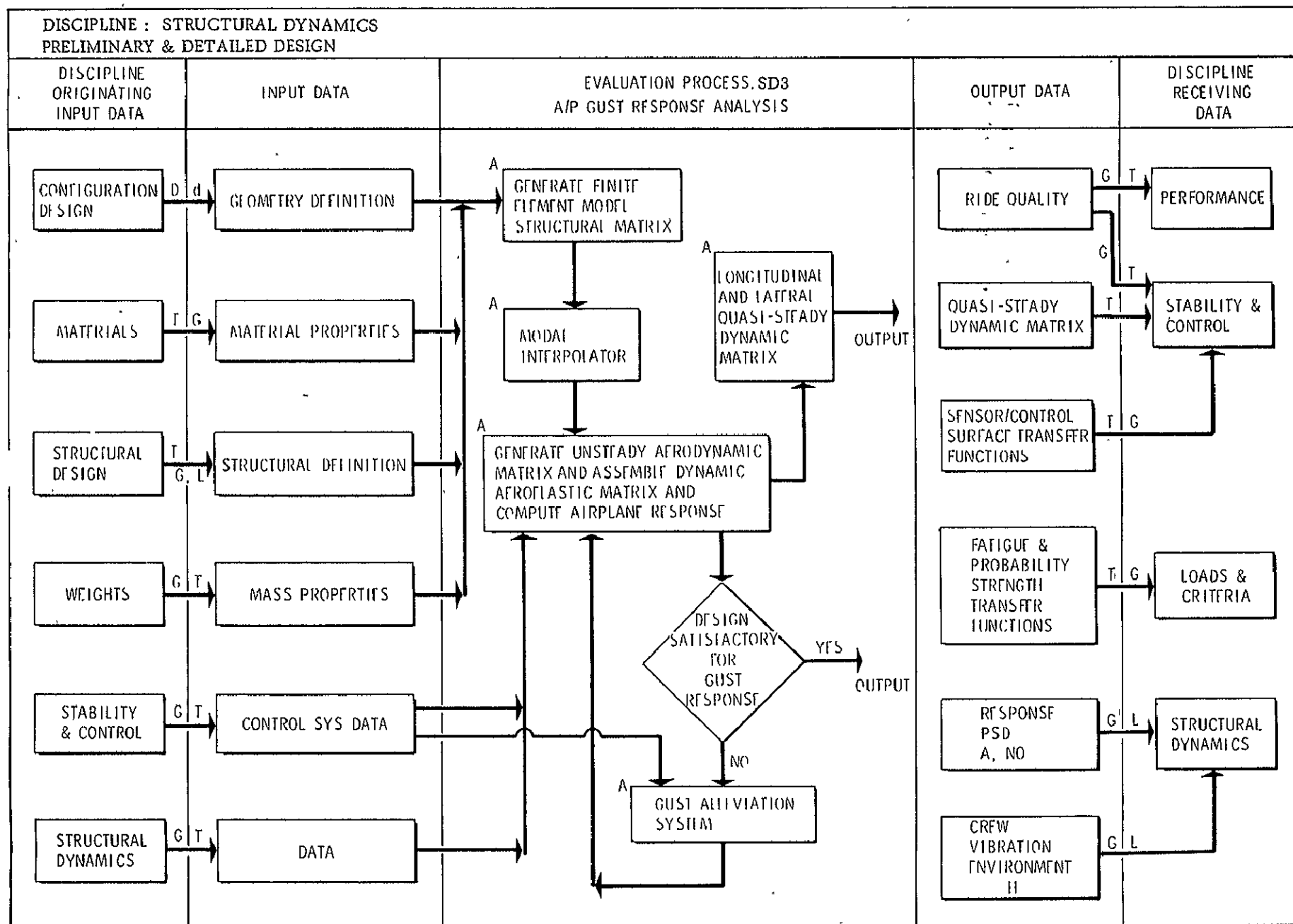


Figure 3-127. Aircraft Gust Response Analysis

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- FLUTTER
- GUST RESPONSE

SYMMETRIC ANALYSIS

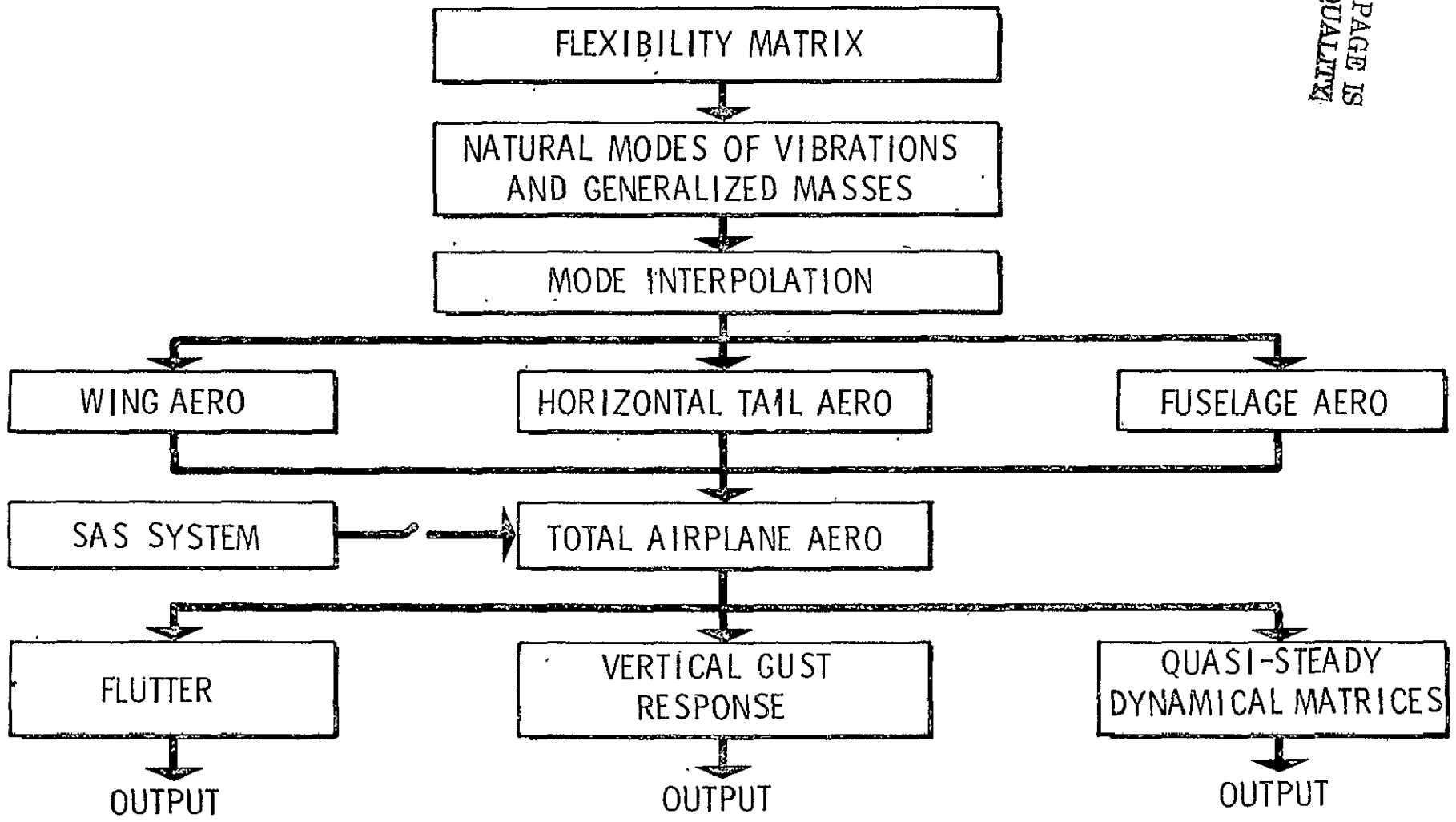


Figure 3-128. Flow of Programs, Symmetric Analysis

- FLUTTER
 - GUST RESPONSE
- } ANTISYMMETRIC ANALYSIS

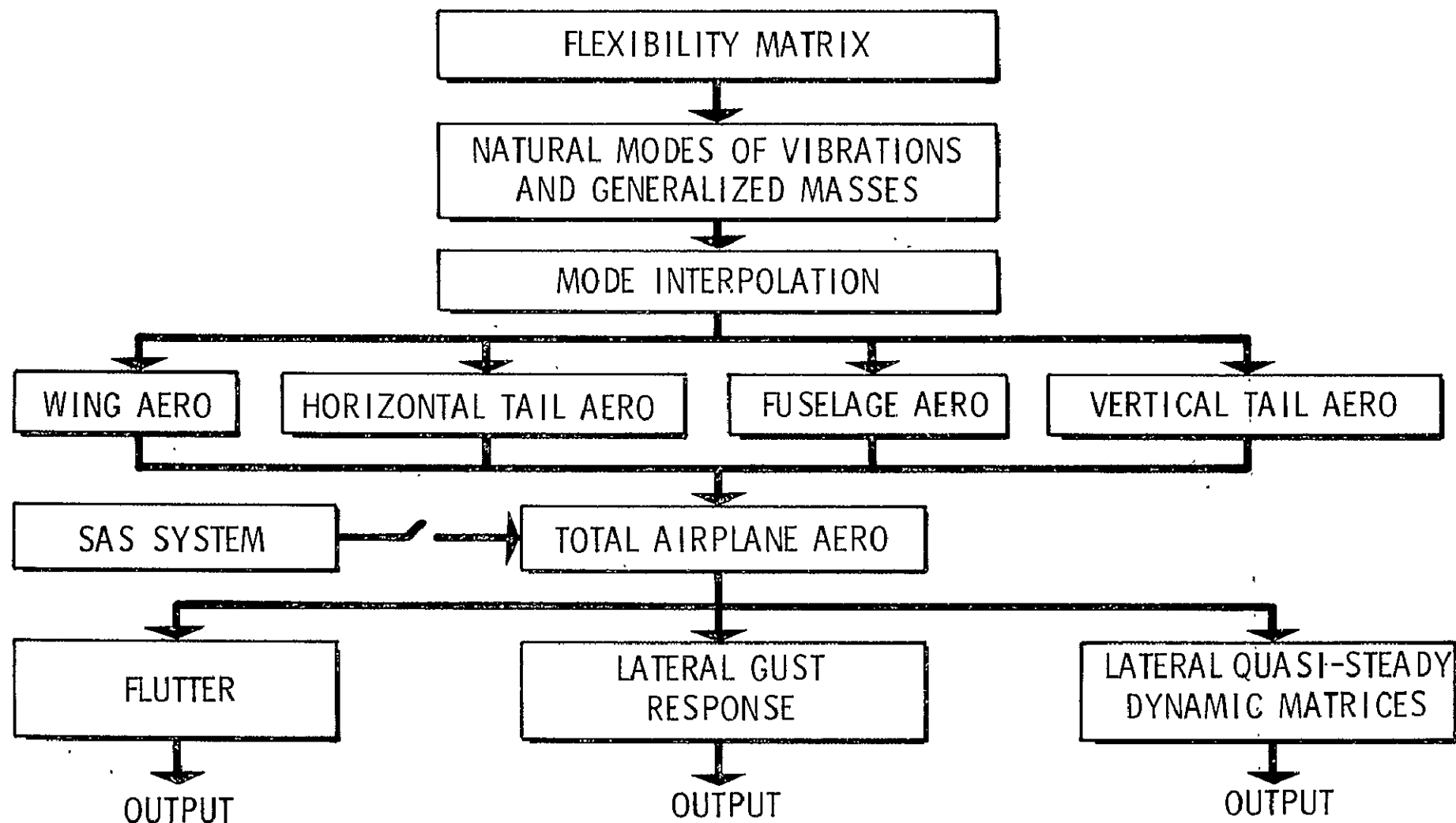


Figure 3-129. Flow of Programs, Antisymmetric Analysis

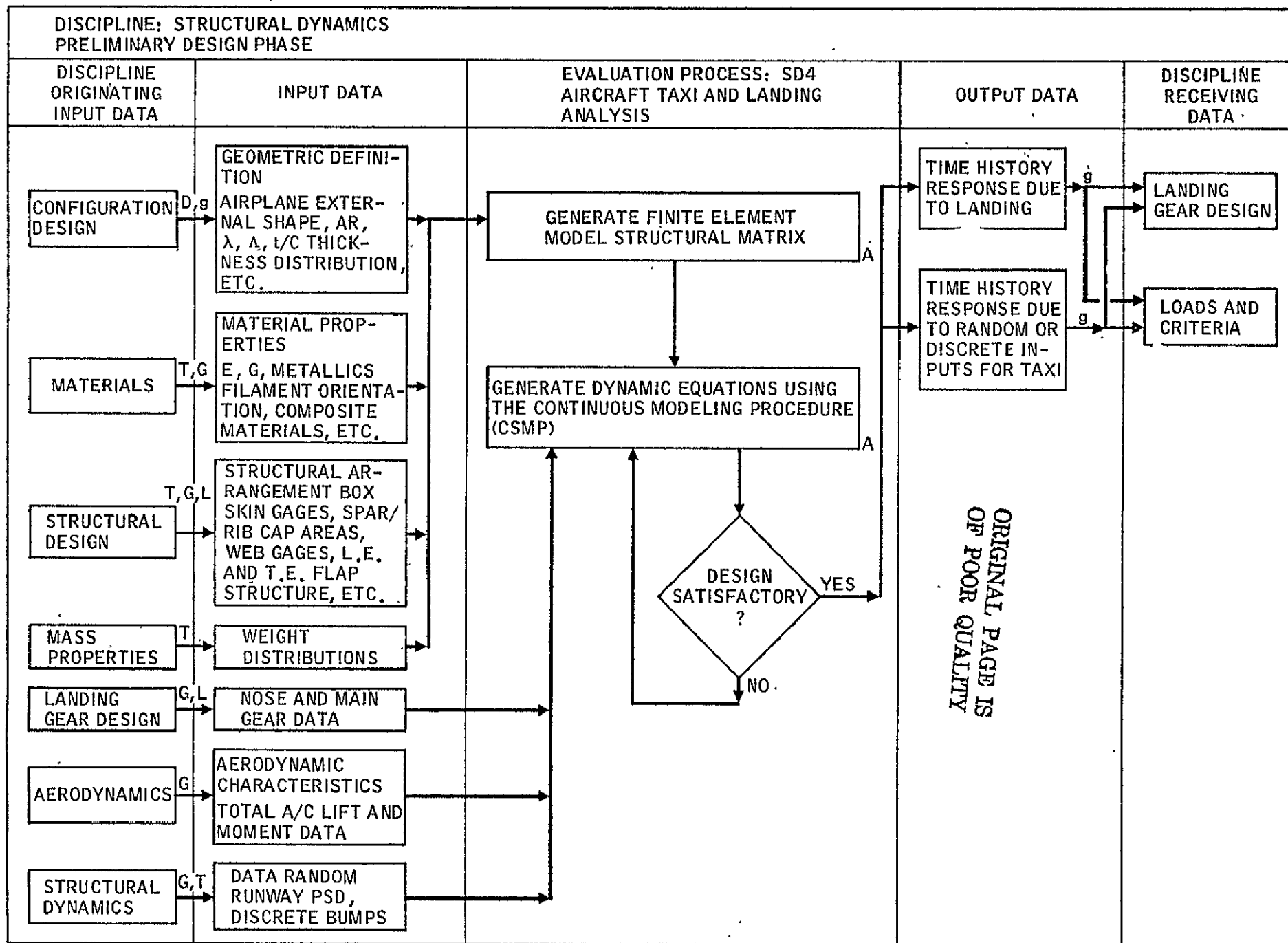


Figure 3-130. Aircraft Taxi and Landing Analysis.

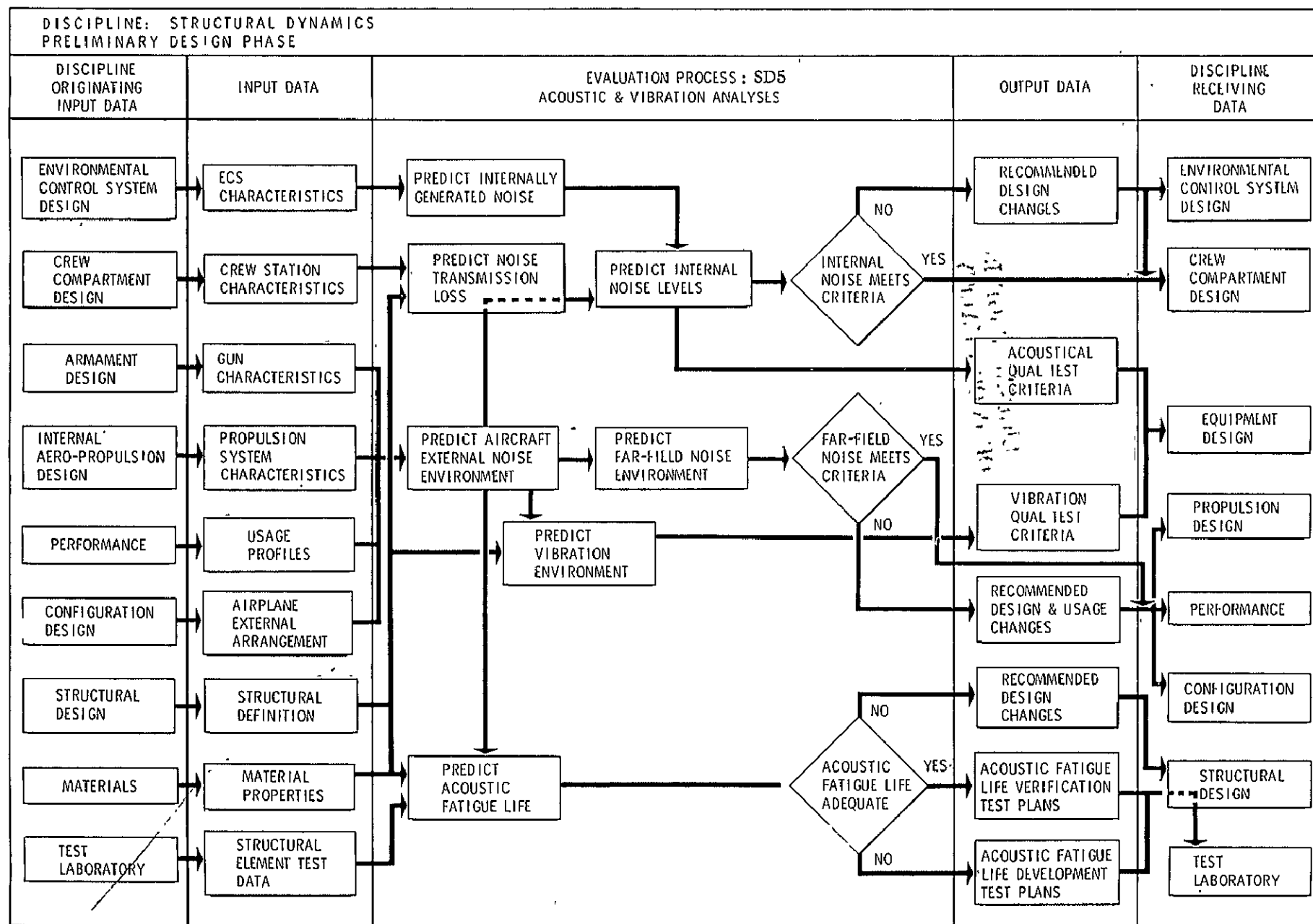


Figure 3-131. Acoustic and Vibrations Analysis

TABLE 3-15. THERMAL ANALYSIS CEP'S AND COMPUTER PROGRAMS

TASKS	CEP	Design Phase		
		C	PD	DD
Aerothermal Environment Analysis	T01	x	x	x
1. Flow Field				
2. Cold Wall Heat Flux				
3. Radiation Equilibrium Temperature				
Finite Difference Structural Temperature Analysis	T01	x	x	x
<u>COMPUTER PROGRAMS</u>				
P5613 Aerodynamic/Structural Heating		x	x	
P2162 Variable Boundary Heat Conduction Program		x	x	x
P4560 Thermal Analyzer			x	x
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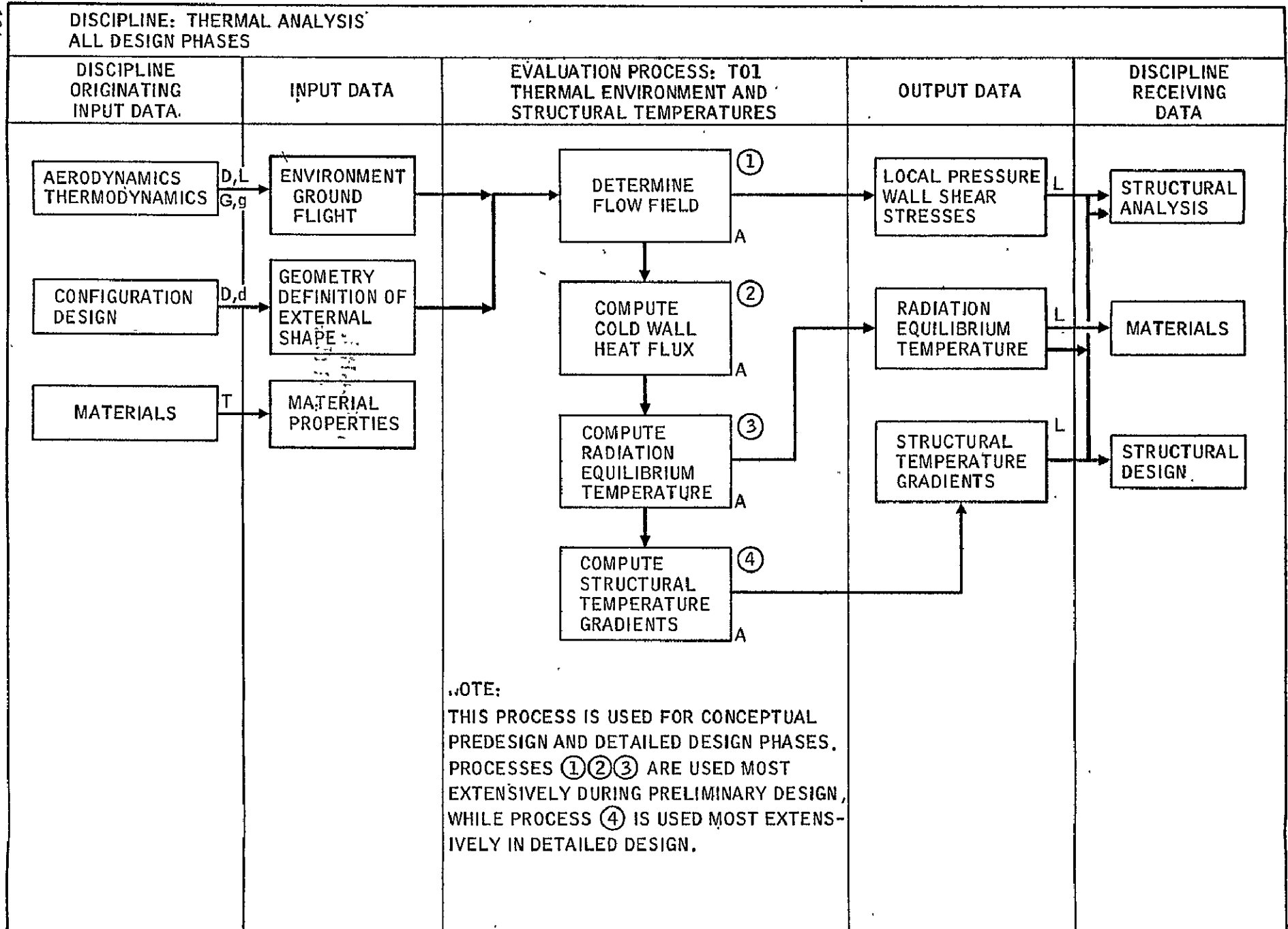


Figure 3-132. Thermal Environment and Structural Temperatures

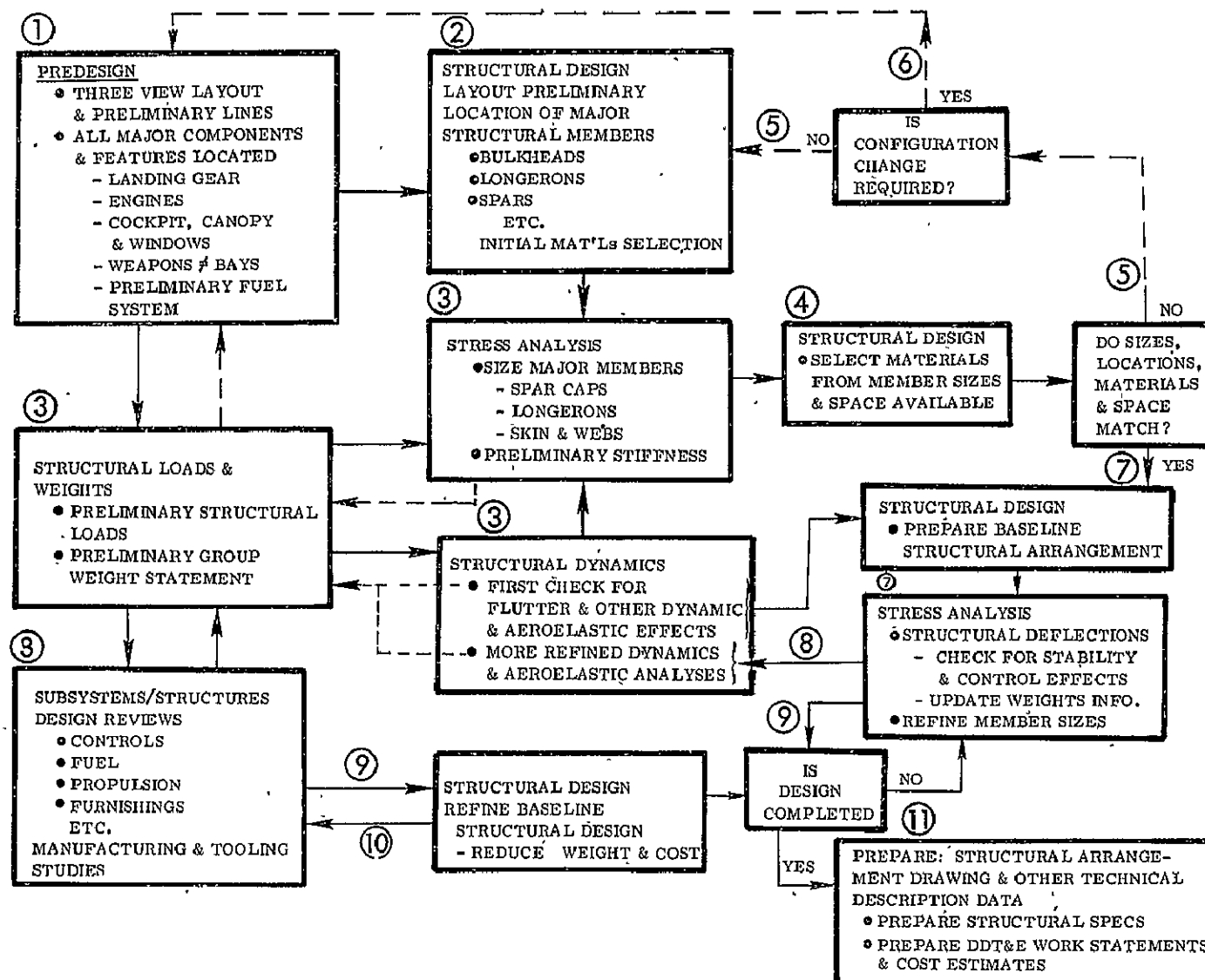


Figure 3-133. Preliminary Structural Design Process

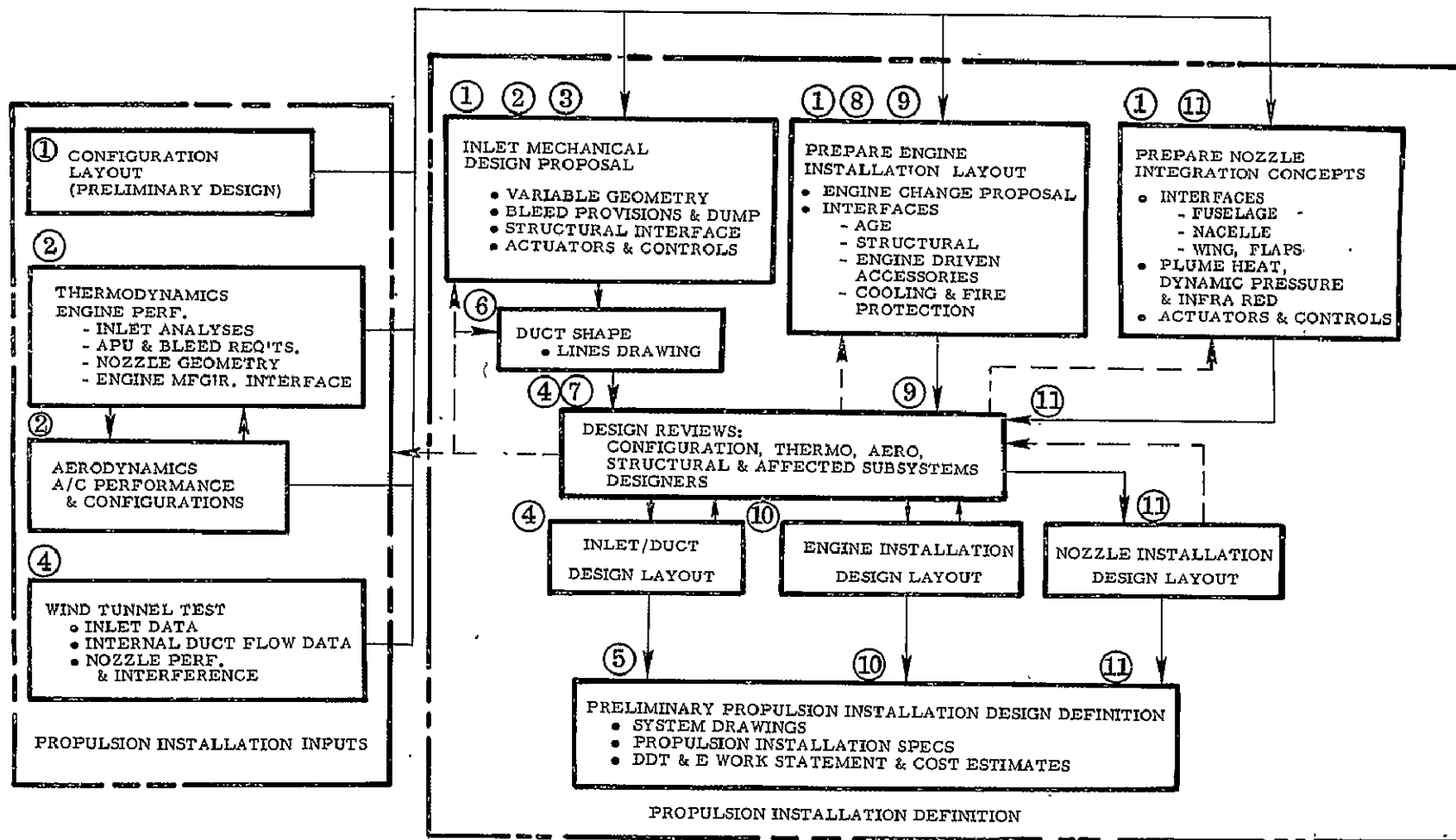


Figure 3-134. Preliminary Propulsion Installation Definition

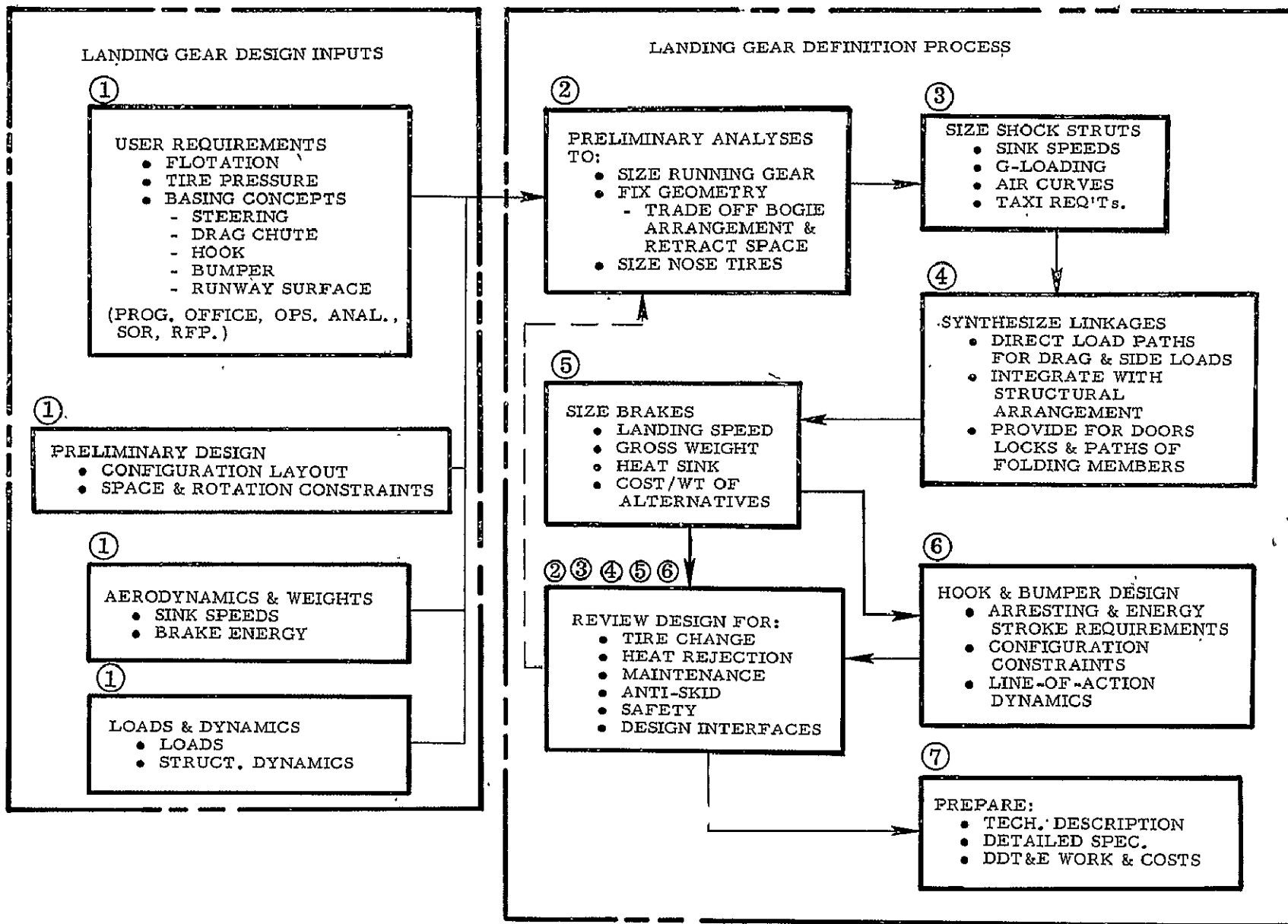


Figure 3-135. Preliminary Landing Gear Definition

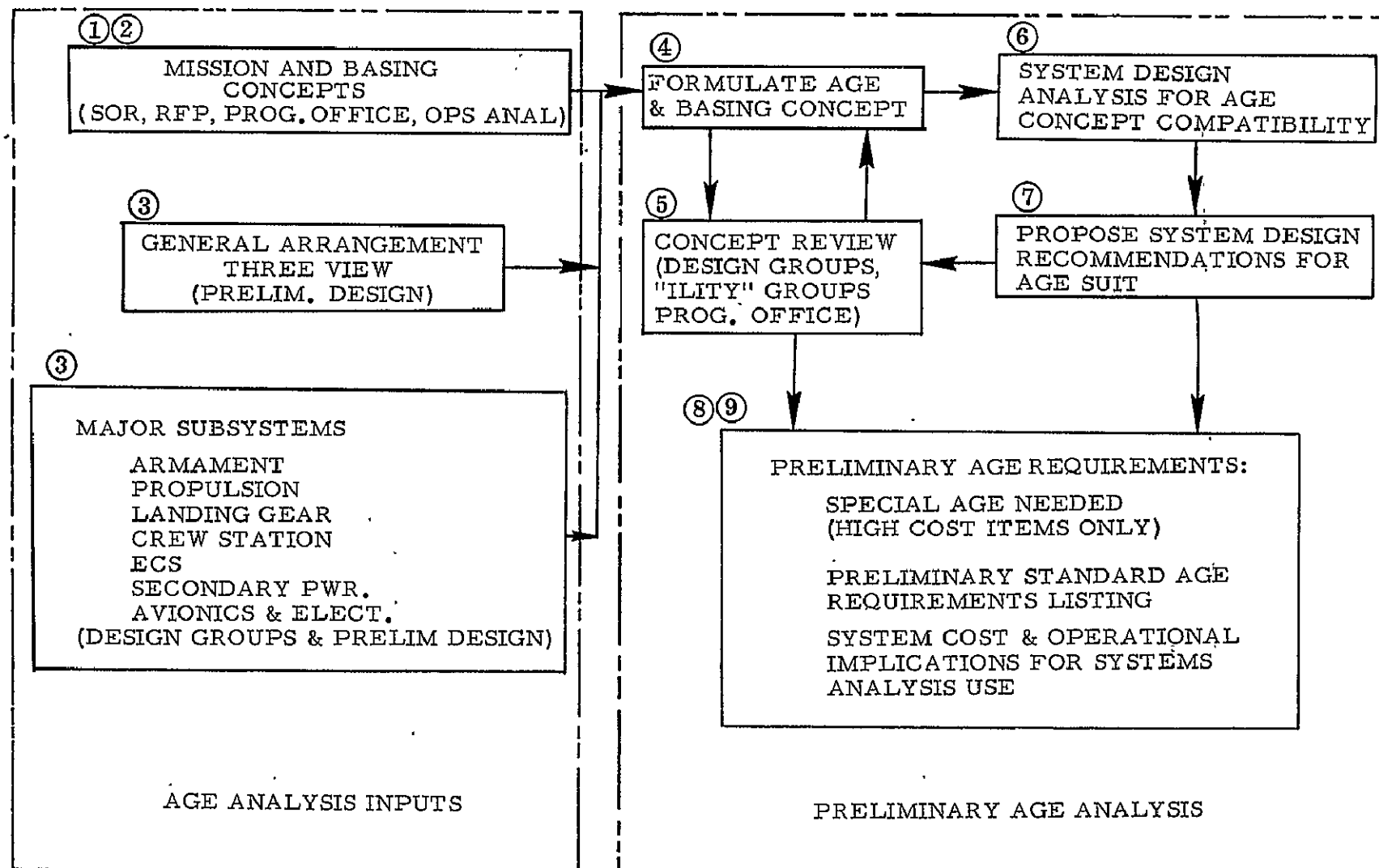


Figure 3-136. AGE Analysis for Preliminary Design

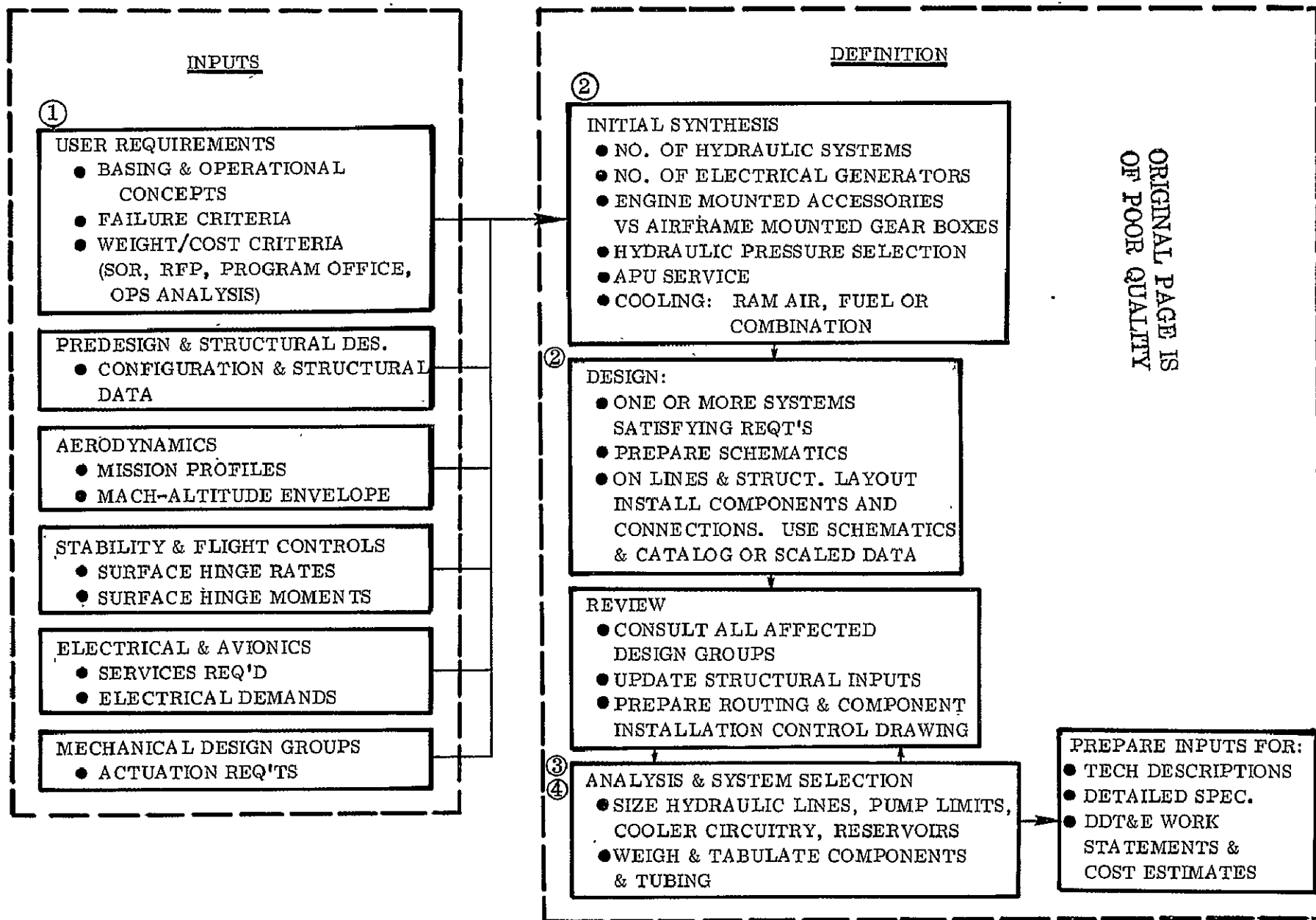


Figure 3-137. Secondary Power System Preliminary Design Definition Process

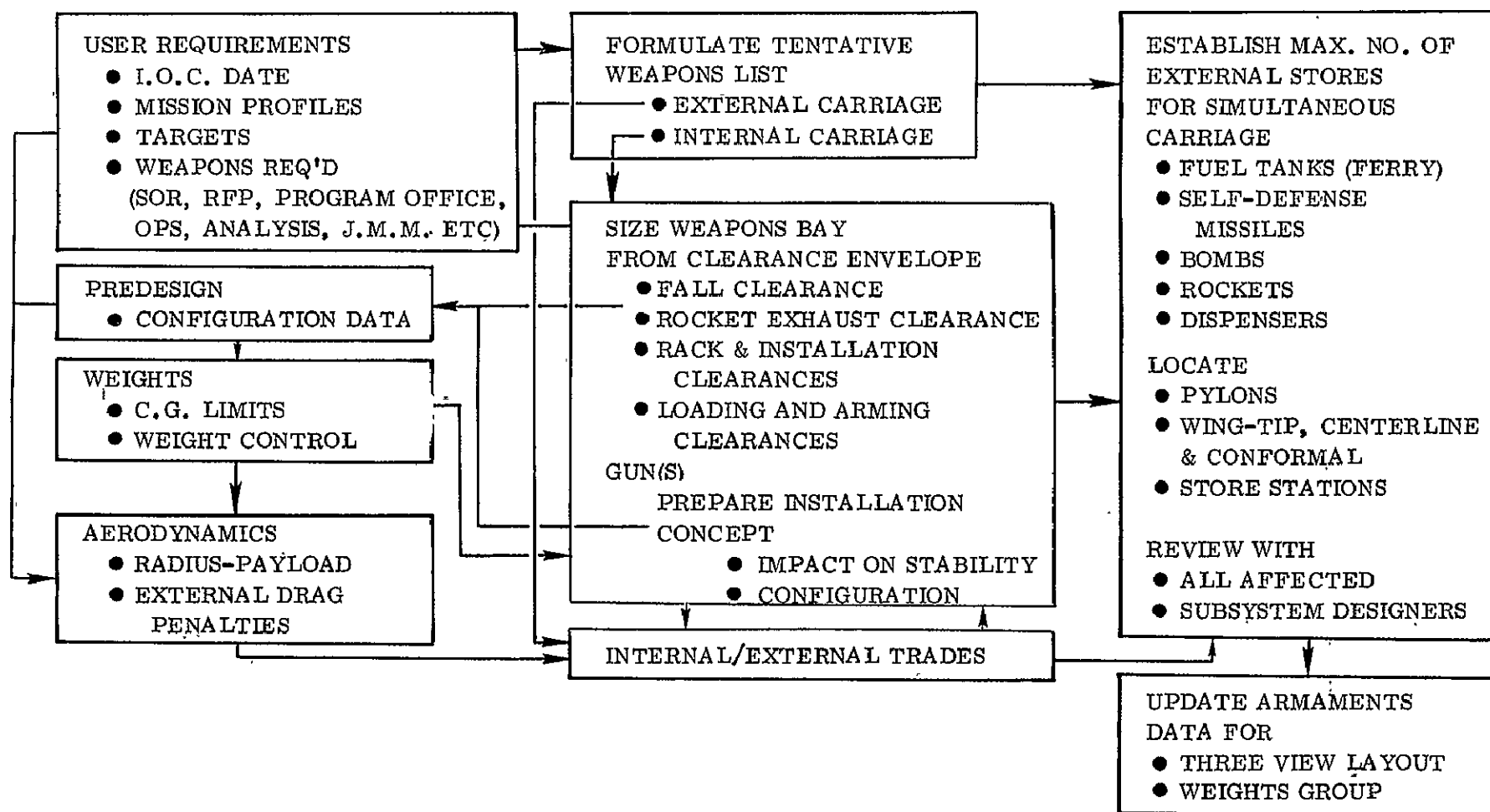
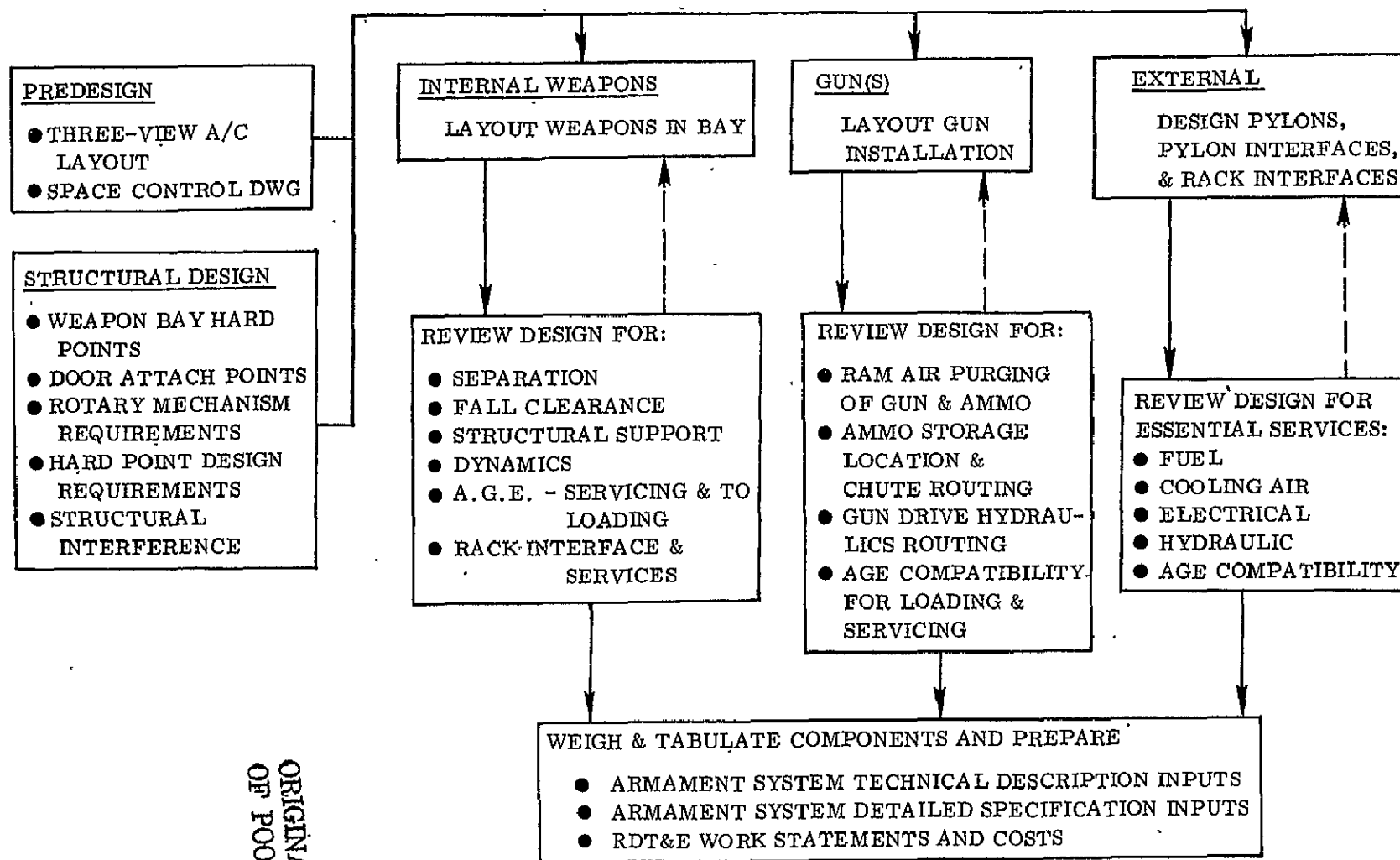


Figure 3-138. Conceptual Armaments System Design Process



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Figure 3-139. Preliminary Armament System Definition